POWER PLANT ENGINEERING

Established Over 34 Years

VOL. XXXIV CHICAGO, JUNE 1, 1930 No. 11

EDITORIAL STAFF — ARTHUR L. RICE, Editor; R. E. TURNER, Managing Editor; A. W. KRAMER, Associate Editor; CHESTER R. EARLE, Associate Editor; RICHARD H. MORRIS, Associate Editor; EDWARD J. KUNES, Associate Editor

Contents of this Issue

	Page
Calumet and Arizona Mining Co. Builds New Power Plant at Lowell. By R. R. Foster	604
Recent Developments of the Benson Boiler. By H. Gleichmann	612
Oil and Gas Power Division, A. S. M. E., Meets at Penn State	613
Boiler Feedwater Purification Methods—II. By H. A. Kuljian	614
The Field for Air-Cooled Refractory Furnaces. By Robert C. Denny	617
Program for A. S. M. E. Spring Meeting, June 9—12	619
Selecting Stokers for New England Fuel. By R. A. Foresman and Donald J. Mosshart	620
Electric Boilers Find Wide Use in Industry	623
Operating Code Manual for Power Plants	626
Care of Switchgear Contracts. By W. E. Warner	626
Reclaiming Heat from Internal Combustion Engines. By L. M. Jordan	627
Control Equipment for Synchronous Motors—IV. By C. P. Robinson	630
Electricity—What It Is and How It Acts. By A. W. Kramer	633
The 53rd N. E. L. A. Convention at San Francisco	636
Operation of Moccasin and Early Intake Plants. By C. W. Geiger	637
Americans Will Preside at Important Sessions of World Power Meeting	638
Industrial Substations—II. By Ottomar H. Henschel	639
Compressed Air System Explosion. By E. O. Edney	641
Soldering Aluminum. By Philip N. Emigh	642
Belt Length Easily Figured. By W. F. Schaphorst	643
Dollars and Sense Steam	644
Watch the Automatic Sprinkler System. By Warren L. Wilmarth	645
Homemade Float Valve	647
Industrial Conveyor Maintenance	648
Letters Direct from the Plant: Baffle Change Reduces Moisture in Steam. Superheater Maintenance. Locating Furnace Air Leaks. Cross Fitting Makes Unique Steam Separator. Diesel Engine Cooling Water. Keyways Repaired by Welding. Simple Leveling Device.	650
Questions and Answers: Tank Capacity Determination. Steam Injection Nozzle Proportions	653
Editorial Comment: Private and Public Utility Power. Power Control Through Heavy Current Tubes. Electric Clocks Indicate Quality of Service. By-Product or Waste Fuel	654
Crawler-Mounted Flight Conveyor	656
Stoker for Scotch Marine Boilers	656
Flow Proportioner for Corrosive Solutions	656
Rotrex Strainer	657
Pipe and Fittings Tongs	658
Combination Pump Valve	658
Concentrometer, a Blowdown Meter	658
The Philip Carey Co. to Make New Insulation	659
New Motor Starting Ammeter	659
News Notes	660
Catalog Notes	660
Power Plant Construction News	662

Published on the 1st and 15th of each Month by the
Technical Publishing Co., 53 West Jackson Blvd., Chicago
New York Office, 171 Madison Avenue

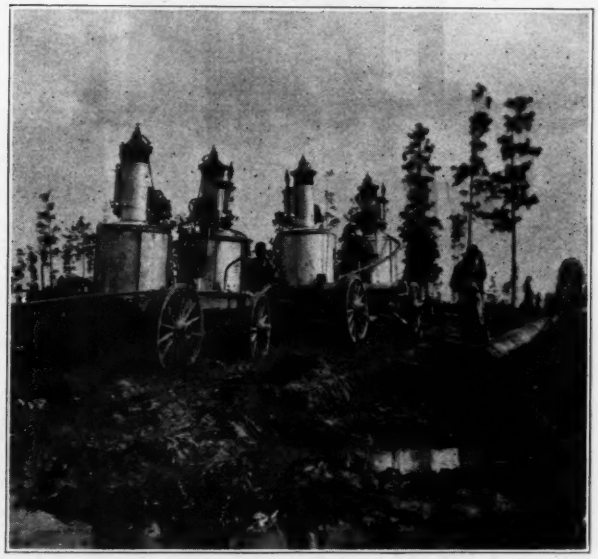
Subscription price $2.00 a year in the United States and possessions. Canada $2.75 a year. Other countries $3.50 a year. Single copies 15 cents.

Copyright 1930, by Technical Publishing Co.

Entered as second class matter May 1, 1908, at the Post Office at Chicago, Illinois, under the act of March 3, 1879.

Member, Associated Business Papers, Audit Bureau of Circulations.

Circulation of this issue 23,650



Fire Engines a la Oklahoma

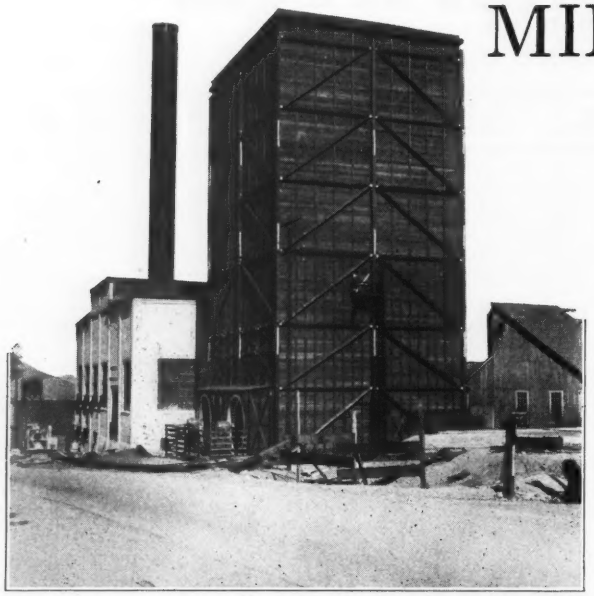
WHEN TOMPKINS CORNERS fire department gets into action, it is such a rare occasion that all the amateur photographers in the village (a total of one) come out to take pictures. If they are lucky, they get away without getting drowned out or burned up or trampled under the feet of the fire horses. And here we have one of those rare pictures. The house had burned down and the fire was put out—no, went out—and the cellar filled with water to prevent further damage. The owner views the ruins of his former home with downcast heart and bowed head. Too bad! Too bad!

Let's not give him too much sympathy, however, for somebody says his insurance was high. Somebody else says he had hinted he did not like his neighbors and numerous other rumors compel an investigation.

But while you are recasting in your mind familiar scenes of years ago, let's see what the photographer says about this picture. Believe it or not, those fire engines are oxy-acetylene tanks out in the oil fields for the purpose of welding a pipe line. It seems that the practice of welding pipe lines has becomes so popular that great financial organizations are connecting cities as far distant as Chicago with the oil and gas fields of Oklahoma and Texas—a most pleasant outdoor sport.

Metals, of course, may be joined in many ways,—screwed, riveted, bolted, welded, soldered—and each method presents peculiar problems. Right now you may be interested in soldering aluminum cables to brass or copper terminals, if so, Mr. Emigh's methods described on page 642 may help you over a difficulty.

CALUMET AND ARIZONA MINING COMPANY *Builds New* Power Plant *at Lowell*



By R. R. Foster
W. W. Jourdin & Co., Inc.

IN THE DESIGN of a modern industrial power plant, there is frequently presented the problem of providing a plant that will not only adequately meet existing conditions but will also be adaptable to quite different conditions at some future date. This problem was encountered and equipment was provided for a wide range of operating conditions, in the design of the recently completed power plant of the Calumet & Arizona Mining Co. at Lowell, Arizona.

In recent years, most of the company's copper mining activities in Arizona have centered about the Junction shaft at Lowell. At this shaft, a large mine hoist and several air compressors were driven by reciprocating engines using saturated steam at 140 lb. per sq. in. G., the steam being generated by sixteen 240-hp. Scotch marine type boilers burning fuel oil.

It had been planned eventually to replace the hoist and compressors with motor-driven units, retaining only those hoists necessary for heating service; however, deterioration of the boilers had progressed so rapidly that it became necessary immediately to replace them in order to insure continued operation of the hoist and compressors until electrification could be completed. Such replacement, while necessary, was undesirable because it would involve the expenditure of considerable money for new equipment to meet only a temporary condition.

Another phase of the problem developed, namely, that of the electrical supply. The principal source of electrical power is the company's smelter at Douglas, 22 mi. east of Lowell, where relatively cheap power is generated by utilizing gases from reverberatory furnaces in waste heat boilers to produce steam for turbo-generators. The power is sent to Lowell over a 3-phase, 60-cycle, 44,000-v. transmission line.

In the past, the most important load carried by this line has been the motor-driven mine drainage pumps on the 2200-ft. level of the Junction mine, which handle water for the entire mining area. Due to the limited sump capacity obtainable in the mine, it is vital that power to these pumps shall not be interrupted. This is

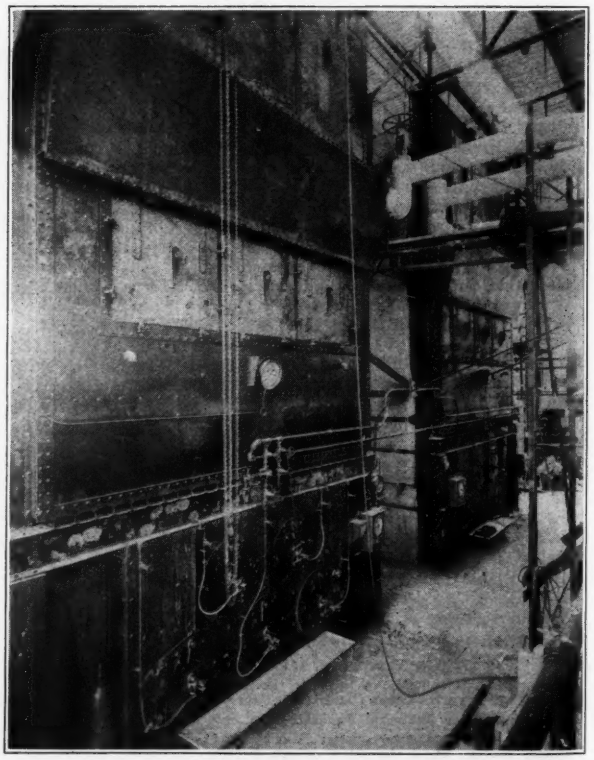


FIG. 1. OIL FIRED BOILERS SUPPLY STEAM FOR ALL PURPOSES

particularly true in the rainy season when seepage water runs high; but, unfortunately, during this season the transmission line is most frequently subject to outage from severe electrical storms.

It was decided, therefore, to purchase three motor-driven compressors immediately and to build a power plant at the mine with sufficient boiler capacity to supply steam to the hoist and engines until they shall have been entirely replaced with motor-driven equipment and, at all times, to insure a power supply to mine pumps. In order to realize the gains possible from higher steam pressures and superheat, a working pressure of 350 lb. was adopted, with steam for the present hoists and compressors supplied at a lower pressure and temperature through a reducing valve and desuperheater. While the power plant was designed to supply the temporary hoist steam demand in addition to electrical power as needed, eventually it will become a standby electrical plant; consequently, operating simplicity and minimum capital expenditure were of utmost importance.

All new equipment is housed in a steel and tile building, 100 ft. wide, with the turbine and compressor room 120 ft. long and the boiler room 80 ft. long. The roof is of 15-yr. composition over a 1-in. layer of Insulite supported by steel deck Truscon ferroboard. All flashings, gutters and downspouts are of copper. There are no walls between the turbine, compressors or boilers, thus permitting ready supervision by a minimum number of operators. A 10-t. crane serves the turbine and compressor room.

Boiler Equipment

Boiler equipment consists of two 725-hp. oil-fired, cross-drum type boilers with superheaters, designed for a maximum working pressure of 400 lb. per sq.in. gage, 200 deg. F. superheat and a maximum rating of 250 per cent.

Fuel oil is stored in two 6900-gal. tanks and is pumped through heaters and supplied to the burners at 175 lb. pressure and 250 deg. F. temperature. Each boiler has five mechanical burners.

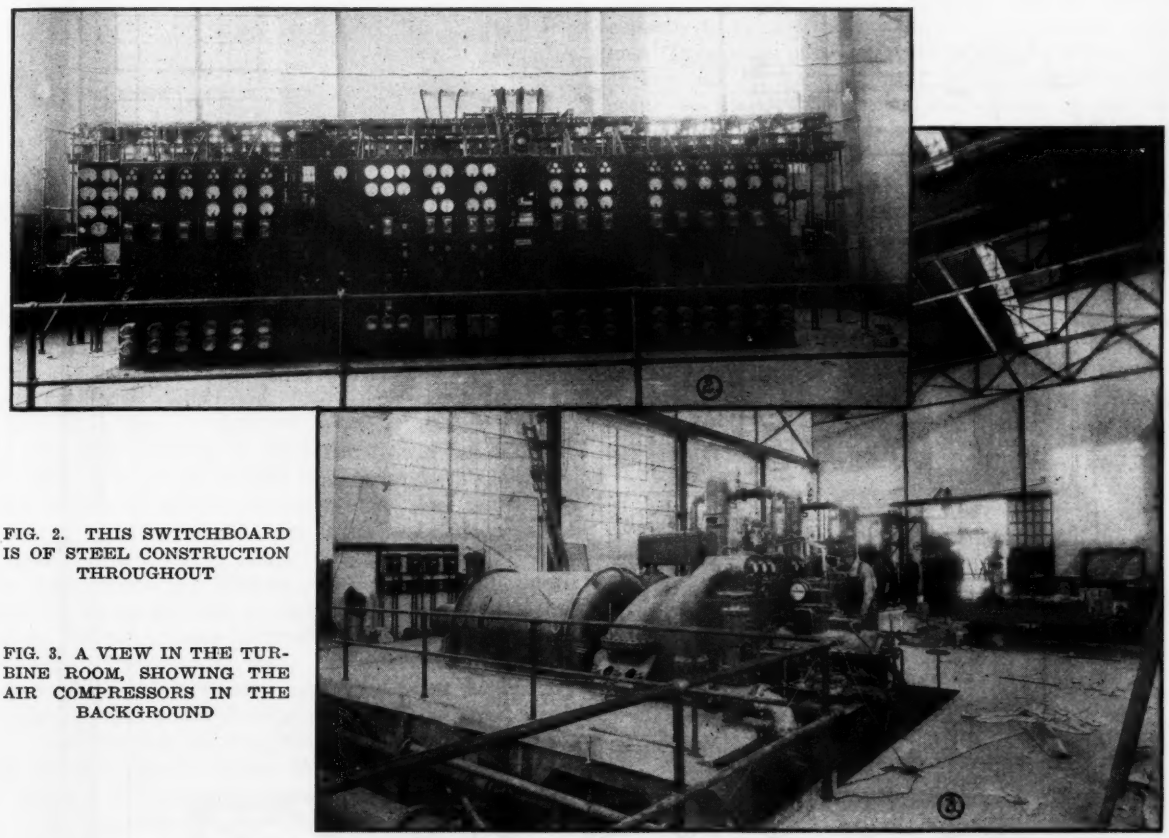


FIG. 2. THIS SWITCHBOARD IS OF STEEL CONSTRUCTION THROUGHOUT

FIG. 3. A VIEW IN THE TURBINE ROOM, SHOWING THE AIR COMPRESSORS IN THE BACKGROUND

Air for combustion is normally furnished to each boiler by a 20,000-c.f.m. forced draft fan driven by a 20-hp. squirrel-cage motor. For emergencies or very high ratings, one 56,000-c.f.m. turbine-driven fan will supply both boilers through interconnecting duct work.

If the stack had been designed to carry both boilers at the high ratings which may occur until the hoists are electrified, it would have been of an excessive height for future operation with turbine load only on the plant. A 9-ft. diameter steel stack was chosen, with a height of 150 t. For ratings above 150 per cent on both boilers, a "booster" induced draft fan is cut in, taking part of the gases from the breeching and discharging it upward through a venturi throat in the stack. This permits ratings up to 250 per cent on both boilers.

The Hagan system of combustion control automat-

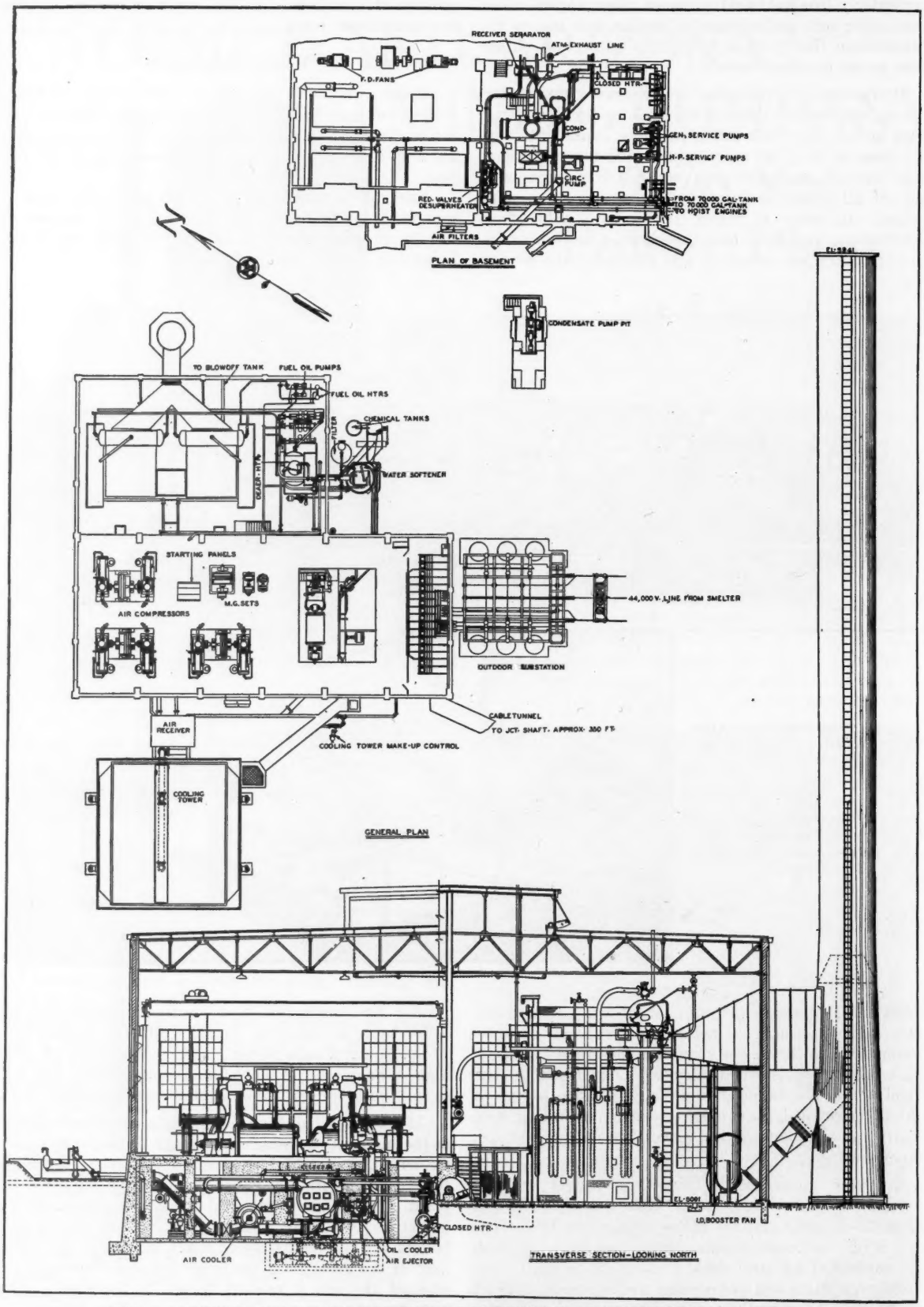


FIG. 4. SECTION AND PLANS SHOWING ARRANGEMENT OF EQUIPMENT AND PIPING

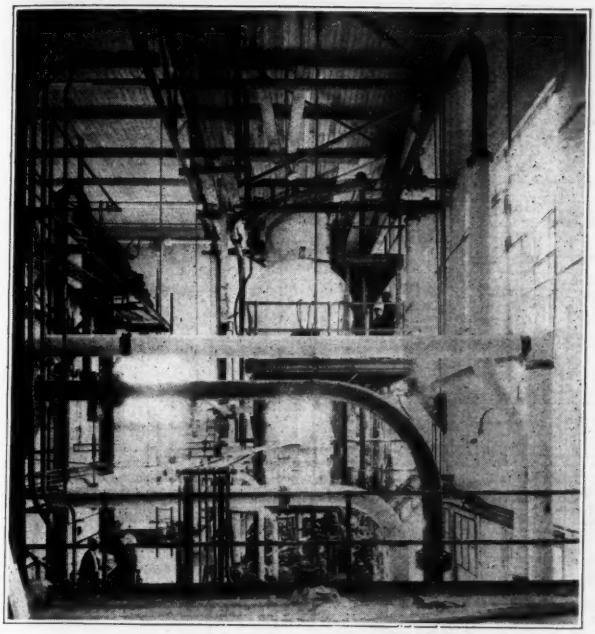


FIG. 5. THE DEAERATING HEATER

ically regulates air and oil supply to the boilers and the furnace draft. It is also arranged to operate a signal when the boiler rating approaches 150 per cent to enable the operator to start the induced draft fan.

Turbine Room

Space is provided in the turbine room for only one turbine, as it is not intended to increase the plant capacity beyond the standby requirements. Any increase in turbine capacity would more logically be made at the smelter central power plant.

The turbine is a 3560-kw., 3600-r.p.m. unit designed for 350 lb. g., 200 deg. F. superheat at the throttle and 28 in. vacuum. Steam is extracted at two points for feed heating. Provision is made for extracting additional steam at the high-pressure extraction point for heating buildings and water for the change house, if desired. The alternator is rated at 3560 kw., 95 per cent power factor, 3750 kv-a., 3-phase, 60-cycle, 2400 v. A direct-connected 25-kw. exciter furnishes excitation. Cooling air for the generator circulates in a closed system and its heat is extracted by a U-fin air cooler.

A 5350-sq.ft. condenser serves the main turbine and is suspended directly from the turbine exhaust flange. It has 1450 admiralty metal tubes, ⅞ in. O.D. and 16 ft. 0 in. long. Steam jet air ejectors of the inter- and after-condensing type take care of air removal. Condensate is removed by either a motor- or a turbine-driven condensate pump.

Since no large body of water is available for condenser cooling water, a cooling tower is used. The tower consists of two 22 ft. 0 in. by 36 ft. 0 in. cells 80 ft. 0 in. high, supported on a concrete foundation and sump. Advantage is taken of the flexibility of the combined natural and forced draft systems for meeting wide variations in loading and atmospheric conditions. Thus, when necessary, natural draft can be supplemented by four 11-ft. 0-in. diameter propeller type forced draft fans, each driven by a 20-hp. squirrel-cage motor.

Circulating water drawn from the cooling tower sump is pumped through the condenser back to the distributing trays of the cooling tower by means of a 6000-g.p.m. motor-driven pump.

Steam Circuits

Simplicity and compactness of the steam circuits are illustrated by reference to the general plans and to the steam and water flow diagram, Fig. 7.

The 350-lb. system is confined to a single header leading from the boiler room to a receiver-separator in the turbine basement from which leads are taken to the main turbine, auxiliary oil pump turbine and the reducing valves for the low-pressure steam supply. The receiver-separator and trap serving it are of sufficient capacity to protect the turbine and low-pressure equipment from slugs of water which might be carried over as a result of the wide load fluctuations which may occur at times. The boiler feed pump turbine and forced draft fan turbine take steam direct from the header.

Low-pressure steam at 175 lb.—75 deg. for the hoist and compressure engines and plant auxiliaries, such as soot blowers, oil heaters and reciprocating pumps, is obtained by passing 350-lb. steam through a reducing valve and cartridge type desuperheater. The low-pressure system is protected by means of an automatic trip valve on the 350-lb. side of the main reducing valve. It will trip shut in case of excessive pressure in the low-pressure system. A secondary reducing valve of smaller capacity then automatically functions to supply steam to the auxiliaries.

Water Circuits

Water used in the new plant is taken from the mine

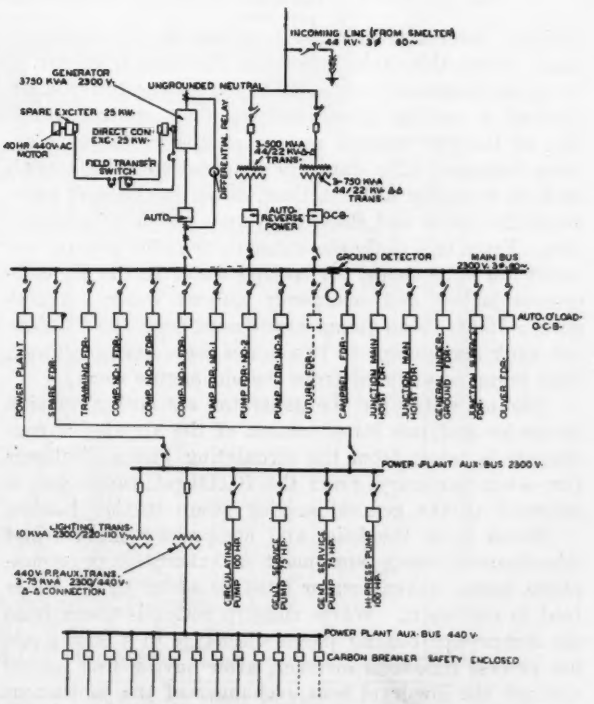


FIG. 6. DIAGRAM OF ELECTRICAL CONNECTIONS

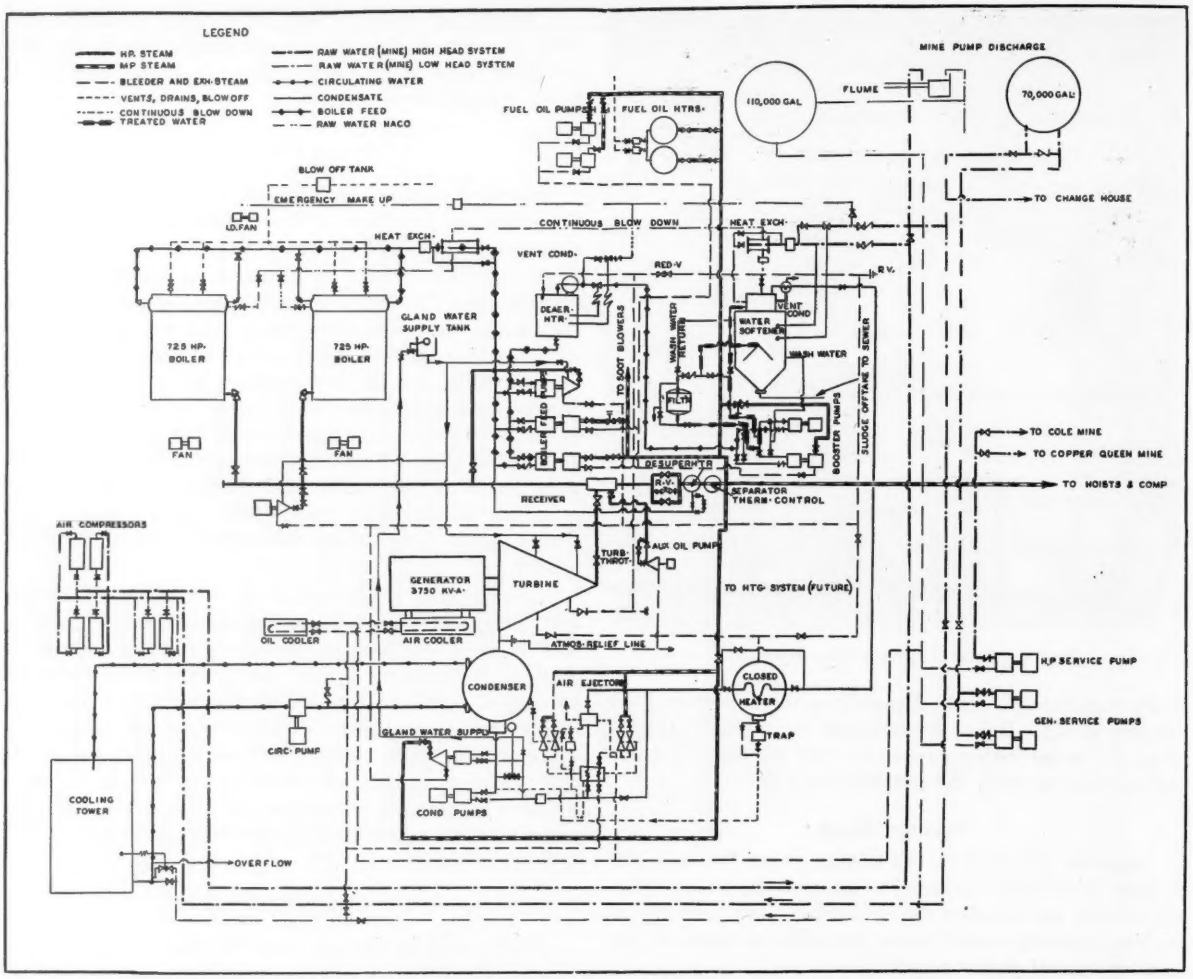


FIG. 7. FLOW DIAGRAM SHOWING CONNECTIONS BETWEEN DIFFERENT PIECES OF EQUIPMENT

drainage discharge line and is stored in a 110,000-gal. tank. From this tank, it flows to the suction header of the general service pumps and to the cooling tower sump through a cooling tower makeup float control valve. One of the two general service pumps in the turbine-room basement lifts water as required to a 70,000-gal. tank on a nearby hill. A float switch in the tank automatically starts and stops the pump which is in operation. From this tank, the water returns for general use about the mine shops, for cooling water in the air compressor jackets and emergency makeup water. A 250-g.p.m., 750-ft. head pump also draws from the 110,000-gal. tank and pumps to two mines some distance away. This pump was moved from the old engine room.

Cooling water for the generator air cooler, turbine air cooler and raw water section of the air ejector condensers is taken from the circulating pump discharge (or, when necessary, from the 70,000-gal. tank) and is returned to the general service pump suction header.

Steam from the hoist and compressor engines and miscellaneous shop equipment is exhausted to atmosphere, hence makeup water must be added to the boiler feed to replace it. Warm makeup water is taken from the compressor cooling jacket discharge to a 6000-g.p.h. hot process lime-soda softener, after having first passed through the low-level heat exchanger of the continuous blowdown system. Makeup is controlled by a float valve on the softener. An emergency float valve admits water directly from the 70,000-gal. tank or the city water supply, as desired.

Condensate from the main turbine is pumped through the air ejector inter- and after-condensers, through the low-pressure closed heater and thence to the heating compartment of the water softener. Here it is heated to 202 deg. and joins the treated water leaving the filter. At this point, di-sodium phosphate is added for boiler feedwater conditioning under the Hall Laboratories system. The phosphate is fed by a separate pump but under control of the main chemical proportioner on the softener.

Condensate and treated water are picked up by a motor-driven "booster" pump and pumped to the high-pressure heater which is the direct contact deaerating type, with a 2000-gal. storage tank. Normal water level in the tank is maintained by a float valve controlling the booster pump discharge. An emergency low level float valve can admit city water directly to the deaerator. A reciprocating pump is provided as steam standby against the motor-driven booster pump, as well as for economical operation on very light loads in the future. It also serves to pump condensate and treated water to the deaerating heater while the motor-driven pump is used for backwashing the filter.

Boiler feed pumps take feedwater from the deaerat-

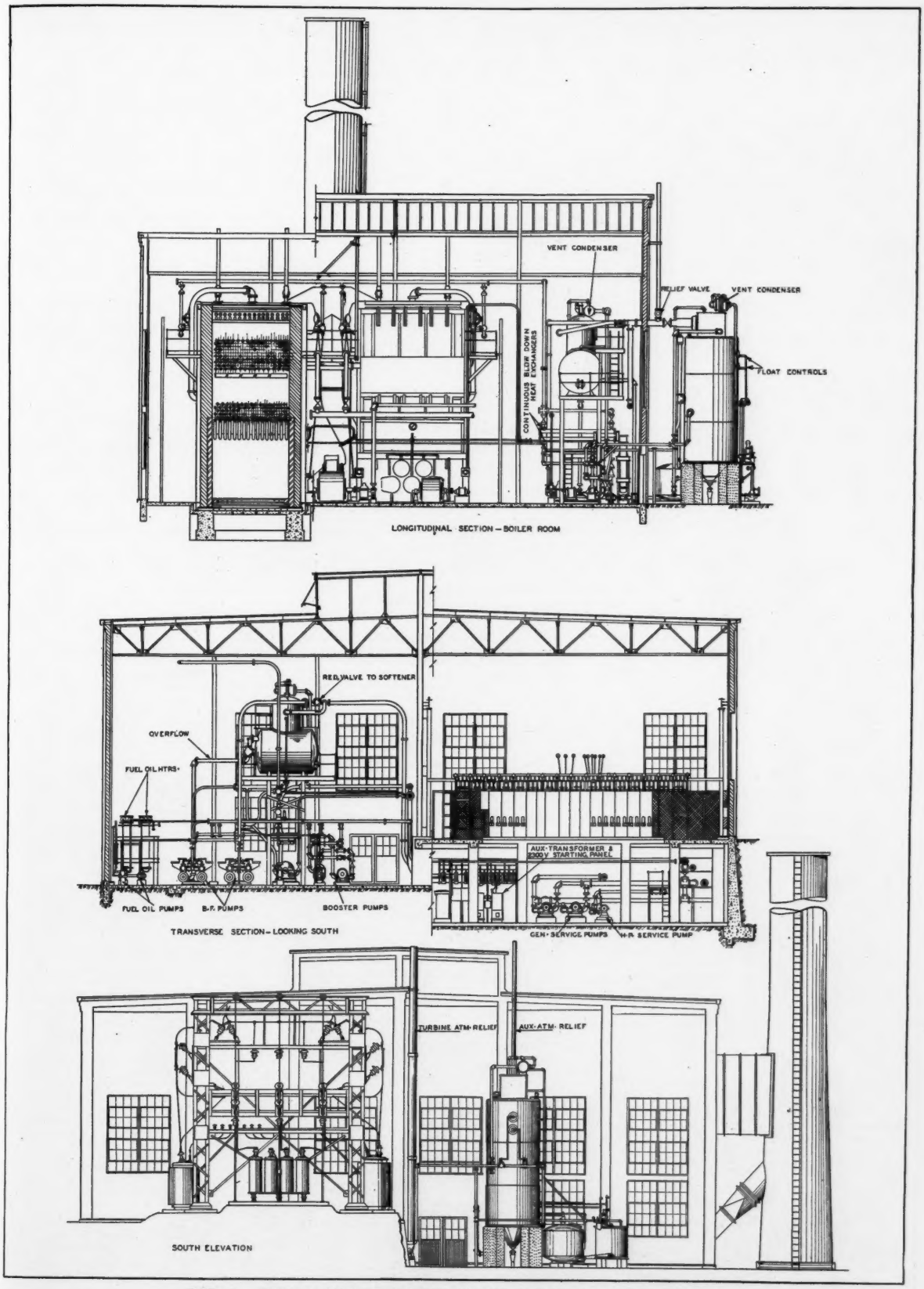


FIG. 8. ELEVATIONS THROUGH VARIOUS PARTS OF THE PLANT

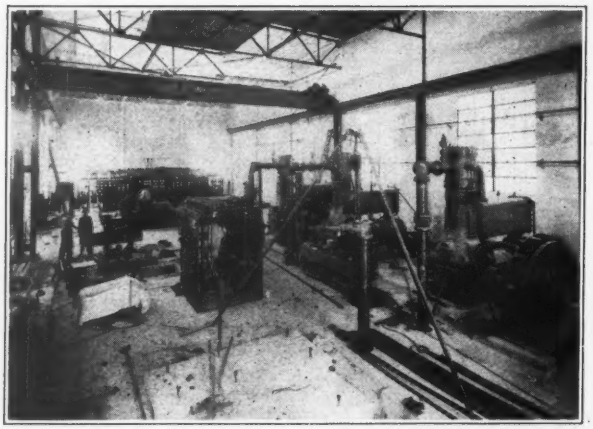


FIG. 9. ANOTHER VIEW IN THE TURBINE ROOM, DURING CONSTRUCTION

ing heater storage tank and pump it through the high heat level heat exchanger to the boilers. The 250-g.p.m. turbine-driven boiler feed pump is operated for normal plant demands but the very light loads incidental to future standby operation may be handled by one of two 150-g.p.m. reciprocating pumps. Since the plant will operate during the major portion of its life on standby operation with light turbine load and no hoist steam load, considerable weight was given the choice of economical equipment for light loads. In this case, because of the high pumping head and small capacity involved for future standby operation, there was a marked difference in cost and efficiency in favor of small reciprocating units over small centrifugal units in combination with the 250-g.p.m. centrifugal. In addition, the need for flexibility and adequacy of steam reserves for both high- or low-load operation led to the choice of the combination including reciprocating instead of small motor or turbine-driven centrifugal units.

Reciprocating auxiliary exhaust steam is segregated from the turbine auxiliary exhaust steam, so that the former goes only to the softener. An oil separator and the chemical treatment in the softener itself remove the possibility of reciprocating pump exhaust steam contaminating the feedwater.

Feed heating steam is extracted from the turbine at the 12-lb. and 50-lb. abs. zones for the closed heater and deaerating heater respectively. Steam condensed in the closed heater is trapped back to the condenser. Auxiliary exhaust steam goes to the softener, and when necessary is automatically supplemented by steam passed

Principal Equipment in Calumet & Arizona Mining Co. Power Plant

BOILER ROOM

2 Walsh-Weidner 725-hp., 400-lb., cross-drum boilers; 336 tubes, 4 in. diameter and 18 ft. 0 in. long; 54-in. drum; Elesco superheaters, Consolidated-Ashcroft safety valves, Diamond Power Specialty Co. soot blowers, Yarway tandem blowoff valves, Copes combination excess pressure and boiler feedwater regulators, Edward boiler feed stop check valves, Reliance water column, Yarway inclined water gage.
10 Morse mechanical type fuel oil burners (5 per boiler).
2 Buffalo Forge Co. 20,000-c.f.m. forced draft fan driven by Westinghouse 20-hp., 1750-r.p.m., squirrel-cage motors.
1 Buffalo Forge Co. 56,000-c.f.m. forced draft fan driven by a Westinghouse 60-hp., 1510—1710-r.p.m., 350-lb.g., 200-deg. superheat, 2-lb. gage back-pressure turbine.
1 Prat-Daniel venturi stack throat and induced draft booster fan. Fan driven by Westinghouse 40-hp., squirrel-cage, 690-r.p.m. motor.
2 Dean Bros. reciprocating fuel oil pumps, 25 g.p.m.
2 Heat Transfer Products, Inc., seamless steel shell fuel oil heaters, with removable tube nest heating oil to 250 deg. at 250 lb. g. maximum pressure.
2 Andale oil suction strainers and 2 discharge strainers, Hagan automatic combustion control system.

TURBINE ROOM

1 Westinghouse 3600-r.p.m., 3560-kw. turbine, designed for 350 lb. per sq.in. g., 200 deg., 28 in. vacuum, 2-stage non-automatic extraction for feed heating. Generator: 3560-kw., 95-per cent p.f. (3750-kv-a.), 2400-v., 3-phase, 60-cycle, welded steel construction. Exciter: 25-kw., 125-v., direct connected.
1 Griscom-Russell U-fin, 3740-sq.ft. generator air cooler.
1 Andale turbine oil cooler.
1 Elliott 5350-sq.ft., 2-pass surface type condenser.
1 Elliott twin 2-stage steam jet air ejector with inter- and after-cooler.
1 Cameron condensate pump, 90 g.p.m., 115-ft. head, driven by Westinghouse 10-hp., 1750-r.p.m., squirrel-cage motor.
1 Cameron condensate pump, 140 g.p.m., 125-ft. head, driven by an Elliott 10-hp., 1750-r.p.m., noncondensing steam turbine.
1 Dean Hill 6000-g.p.m., 45-ft. head circulating pump, driven by a Westinghouse 100-hp., 690-r.p.m., squirrel-cage motor.
2 Dean Hill 1000-g.p.m., 175-ft. head, single-stage, general service pumps, driven by Westinghouse 75-hp., 1750-r.p.m., squirrel-cage motors.
1 Allis-Chalmers 250-g.p.m., 750-ft. head, 4-stage, high-pressure, general service pump, driven by an Allis-Chalmers 100-hp., 3500-r.p.m., squirrel-cage motor. (From old plant.)

FEEDWATER CIRCUIT

1 Cochrane 160-sq.ft., 6-pass. closed heater.
1 Cochrane 116,000-lb. per hr. deaerating heater and 2000-gal. storage tank.
1 Cochrane 6000-g.p.h., lime-soda, hot process water softening apparatus.
1 De Henszey continuous blowdown system.
1 Dean Hill Co. 250-g.p.m., 231-ft. head, single-stage centrifugal booster pump, driven by a Westinghouse 30-hp., 1750-r.p.m., squirrel-cage motor.
1 Dean Bros. 225-g.p.m., 231-ft. head reciprocating booster pump, steam end designed for 175 lb. g., 75 deg. superheat, 2 lb. g. back pressure.
1 Dean Hill Co. 250-g.p.m., 1040-ft. head, 4-stage, centrifugal boiler feed pump, driven by a Westinghouse 135-hp., 3550-r.p.m. turbine, designed for steam conditions of 350 lb., 200 deg., 2 lb. g. back pressure.
2 Dean Bros. Co. 150-g.p.m., 1040-ft. head reciprocating boiler feed pumps, steam end designed for 175 lb. g., 75 deg. superheat, 2 lb. g. back pressure.

COMPRESSORS

3 Sullivan twin type, 2-stage, 3760-c.f.m., 100-lb. per sq.in. discharge pressure compressors, driven by Westinghouse 700-hp., 225-r.p.m., synchronous motors. One compressor fitted with 48-in. C-H magnetic clutch.

ELECTRICAL

1 Bullock Elec. Mfg. Co. 150-kw., 600-r.p.m. motor-generator tramming set.
1 Westinghouse 50-kw., 1200-r.p.m. motor-generator tramming set.
1 General Electric 25-kw., 900-r.p.m. motor-generator set, auxiliary exciter.
(Above motor-generator sets from old plant.)
Westinghouse 14-panel main switchboard, bus structure and circuit breakers.
Westinghouse 3-panel, 12-circuit auxiliary switchboard.
3 Westinghouse 75-kv-a., single-phase, 2300/440-v. auxiliary transformers.
1 Westinghouse 10-kv-a., single-phase, 2300/220/110-v. lighting transformer.
3 Allis-Chalmers 750-kv-a., 44,000/2300-v., single-phase transformers. (From old substation; bushing and covers altered for outdoor service.)
3 Allis-Chalmers 500-kv-a., 44,000/2300-v., single-phase transformers. (From old substation.)
Outdoor substation horn gap switches, buses and insulators.....General Electric Co.
Outdoor substation steel structure.....Kansas City Structural Steel Co.
Building .....Kansas City Structural Steel Co.
Stack and breeching.....Kansas City Structural Steel Co.
Crane, 10-t. .....Box Crane Co.
Cooling tower...Foster Wheeler Corp.
Reducing valves, 350 lb. to 175 lb., and pump governor valves.....Mercon Reg. Co.
Automatic trip valve.....Schutte & Koerting Co.
Desuperheater, cartridge type.....Elliott Co.
Steam traps .....Armstrong Machine Works
Draft gages, boiler meters, steam flow meters and boiler feedwater meters.....Bailey Meter Co.
Indicating thermometers .....C. J. Tagliabue Mfg. Co.
Indicating gages.....Ashton Valve Co.
Bleeder steam and makeup water constant pressure valves, atmospheric relief valve, heater relief valve and closed heater drain trap .....Atwood & Morrill Co.
Valves, 400 lb.....Lunkenheimer
All piping, fittings and 125-lb. and 250-lb. valves .....Crane Co.
Gaskets.....Garlock Packing Co.
Insulation.....Johns-Manville, Inc.

through a reducing valve from the 50-lb. extraction line. At times, should there be an excess of auxiliary exhaust steam over that required in the softener, a spill valve set at 1 lb. gage will release the excess to the closed heater. Thus a balance is automatically maintained regardless of the pressures in the extraction heaters and the water in the softener is maintained at boiling point and atmospheric pressure at all times.

Instruments

Boiler meters record the output of each boiler. Steam flow meters record directly the steam consumption of the main turbine, and the hoist and compressor engines. These, together with recording venturi meters in the condensate, makeup and boiler feed lines and suitable indicating thermometers and gages, provide data for heat balance calculations and an adequate record of the plant's performance.

Electrical Equipment

Figure 3 is a one-line diagram of the electrical circuits. Power coming into the outdoor substation over the transmission line from the smelter power plant is stepped down from 44,000 to 2300 v. through two parallel banks of delta-delta connected transformers. One bank consists of three 500 kv-a. and the other of three 750-kv-a. single-phase transformers. These were moved from the old outdoor substation near the shaft. Provision is made for replacing the 500 kv-a. transformers with larger units at a future date, should the plant load increase.

Transformers and the 3750-kv-a. generator are tied to the main 2300-v. bus through remote controlled electrically operated oil circuit breakers. Power at 125 v. for the closing solenoids on these breakers is obtained from a Rectox rectifier, instead of a battery. Power for the control circuit for the trip coils on all breakers is obtained separately from a storage battery. This control circuit voltage is 24 v., hence only a small battery installation is required. A 14-panel main switchboard of steel construction provides control for the incoming feeder and generator circuits, and the various outgoing mine, pump, compressor and auxiliary feeders. These latter are protected by remote control manually operated circuit breakers.

The auxiliary feeder supplies the circulating and general service pump motors, a lighting transformer and a 2300/440-v. transformer bank for the auxiliary motors under 75 hp.

Two motor-generator sets supply direct-current power for tramming. A 150-kw., 600-r.p.m. unit normally carries the day load and a 50-kw., 1200-r.p.m. unit is used for light loads and as reserve. A 25-kw., 900-r.p.m. motor-generator acts as reserve against the main unit direct-connected exciter. All three sets were moved from the old engine room, and are placed in the compressor and turbine room.

Ordinarily, the plant is well lighted in the daytime because of the liberal window area provided. In order to insure adequate illumination at all times, three lighting circuits are provided: a 24-hr. circuit, a 12-hr. circuit and an emergency circuit. Power for the latter is supplied by a small gasoline engine-driven d.c. generator. A separate plug circuit is provided for miscellaneous light and tool services.

Air Compressors

The electricity-driven air compressors, which replace the old steam-driven units, are housed in the new plant in the same room with the turbine. There are three twin type two-stage compressors rated at 3760 c.f.m. actual air delivery at 100 lb. pressure at the plant elevation of 5100 ft. Each twin unit is driven by a 700-hp. synchronous motor. The left-hand element of one unit can be uncoupled from the motor by means of a 48-inch Cutler-Hammer magnetic coupling. The other two units are equipped so that magnetic couplings may be added later if desired.

Air for the compressors is taken from outside the building through filters in the basement wall into a large receiver compartment. Suction pipes lead from this compartment directly to the compressors. Compressed air is led outside to a receiver, which is the shell of one of the old boilers, and from it to the mine shaft.

The plant was designed by W. W. Jourdin & Co., Inc., New York, and erected by the Calumet & Arizona Mining Co., Warren, Ariz., under the supervision of H. A. Clark, general manager, and E. F. Irving, master mechanic.

Hudson Ave., to Add Two 160,000 Kw. Units

Announcement is made by Matthew S. Sloan, president of the New York Edison Co. and associated companies, that bids are being sought for two new turbine-generators, each of 160,000 kw. capacity, for the Hudson Avenue Station of the Brooklyn Edison Co.

One of the machines is to be installed next year and the second in 1932. They will raise the capacity of the station to 770,000 kw., or more than 1,000,000 hp. It is estimated that the total cost of the generators, boilers, and other equipment necessary will be about $14,000,000.

"New York City's demand for electric service is increasing," said Mr. Sloan, "so that it is necessary to order these new generators, in spite of the fact that within the last year we have put into service two 160,000-kw. units in Hell Gate Station and one of the same capacity in the East River Station, and a 110,000-kw. unit is going into service this fall in the Hudson Avenue Station. Since the use of electric power is an accurate measure of business conditions in a community, this order may be taken as evidence of present satisfactory conditions and our confidence in the future. When these generators are in service, the Hudson Avenue Station will have a total capacity larger than the present capacity of 810,000 hp. at Hell Gate, which is now the largest steam plant in the world."

With the 110,000-kw. generator now under construction and the two new units installed, all the space in the turbine room of the Hudson Avenue Station will be occupied. Space for eight boilers is already provided, but an extension to the building will have to be built to accommodate two more, as each of the great new generators will be served by a battery of five huge boilers.

Recent Developments of the Benson Boiler

CHANGES IN TUBE ARRANGEMENT AND SHAPE OF BOILER. NEW 300,000-LB. PER HR. UNIT WILL BE IN SERVICE AT LANGERBRUGGE STATION THIS SUMMER. BY H. GLEICHMANN*

GENERAL PRINCIPLES of the Benson boiler generating steam at the critical pressure of 3200 lb. per sq. in. will be known to readers by several articles of the past. A description by the author of the first Benson boiler installation at the cableworks of the Siemens-Schuckertwerke at Berlin, Germany, was found in the July 1, 1928 issue of Power Plant Engineering and moreover parts of a later article published by the author in the July 28, 1928 issue of the "Zeitschrift" of the "VDI," will be remembered by American readers from short translations.

In the meantime, development has been carried on and further experiences have been gained both with respect to the design of the boiler and to the operation of it on a commercial basis.

At the "Technische Hochschule" of Berlin, the small 6500 lb. per hr. oil fired test boiler which has been in operation since November, 1927, has been used since then for research work as well as for routine experimental courses of the students, without any troubles.

Another experimental Benson boiler, of 16,500 lb. per hr. capacity, has been installed at the Bitterfeld plant of the "J. G." dye trust with the special purpose in mind to try low grade bituminous coal firing in connection with the Benson system, which, although first looked at as somewhat questionable, has proved to be quite a practical proposition.

The main installations, however, where most of the experiences were gained, are the two pulverized coal-fired Benson boilers at the cable works of the Siemens-Schuckertwerke at Berlin, Germany.

NEW BOILER FOR 75,000 LB. PER HR. IN SERVICE

Number 1 boiler of the cable works has been described in the above-mentioned article in Power Plant Engineering. Since that time, however, the boiler has been remodeled and shows today a quite different arrangement of the heating surface, its maximum capacity now being 77,000 lb. per hr.

Changes have been made in accordance with the new design of No. 2 Benson boiler which was erected nearby and put in operation last summer. The normal capacity of No. 2 boiler is 75,000 lb. per hr. and its maximum capacity 100,000 lb. per hr. The design of this new boiler is shown in the accompanying cross section Fig. 1.

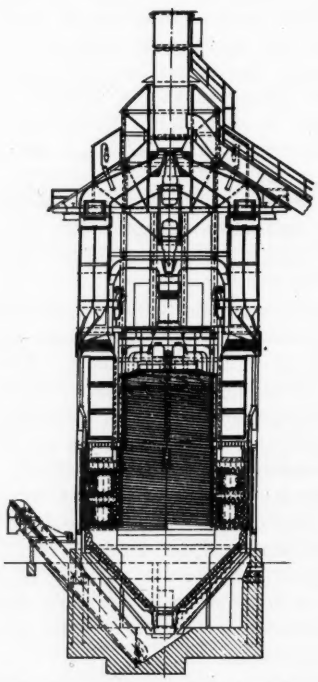
Whereas No. 1 boiler in its first design had straight vertical bundles of tubes in the combustion chamber as well as in the convection zone, it will be seen from Fig. 1 that the radiant heating surface now is made up by helically wound coils and that the convection heating surface consists of horizontally arranged tubes which are also wound as coils.

Straight vertical tubes of the old design had been arranged in several elements which were designed to be taken out separately in case of repairs to be made. It proved to be possible, however, to make repairs right in place inside of the combustion chamber, so that it could be afforded to have the radiant heating tubes of the new design welded together in a rigid system right in place, the advantage of the helical winding being a compensation of possibly uneven heat distribution from the burners and the avoiding of U-bends in which otherwise mud deposits could have been collected.

*Siemens-Schuckertwerke, A. G. Berlin, Germany.

REHEATER REPLACED WITH ECONOMIZERS

Moreover No. 1 boiler, in its old design, had four superheaters and four reheaters in the eight second



CROSS-SECTION OF THE LATEST BENSON BOILER

passes which surrounded the combustion chamber. In the new design of both boilers, however, reheating has been dispensed with entirely, because of the increased initial superheat (860 deg. F.) and the increased back-pressure (1300 lb.) which allows a straight expansion in the turbine.

Instead of the reheater tubes, economizers have been installed. Air preheaters which heat the air for combustion up to 750 deg. F. are used in both boilers.

A most remarkable change that distinguishes No. 2 boiler from No. 1, is that the octagonal cross-section has been abandoned and replaced by the simpler and cheaper square shape. Thus only two second flue passes surround the combustion chamber on two sides opposite to each other, the remaining two sides having only double walls for air preheating and insulation purposes.

No. 1 boiler was first fed with a high percentage of zeolite-softened make-up which resulted in a rather high concentration. Later on, steam transformers were installed to generate the required process steam, so that a closed circuit of pure high-pressure feedwater and steam could be maintained, the small amount of makeup still necessary being evaporated and deaerated before entering the system.

No scale troubles ever have been encountered. Even with the high concentrations of the past, only muddy deposits were found occasionally which could be easily blown down. Pieces cut out of tubes after considerable time of operation showed but a slight red film of iron oxide on the inner surface.

The fact that no hard scale is formed in the tubes of the Benson boiler is understood to be due to the lack of any steam bubbles being formed, which seems to be quite in accordance with the results of the research work done by Messrs. Partridge and White at the University of Michigan.

Tests Made with Low Volatile Coal

Special tests have been run at No. 1 boiler some time ago, with the purpose of investigating the burning qualities of low volatile coal. These tests are interesting in so far, as this boiler had the highest water cooling percentage of any existing boiler so far. (Except for the small top surface, where the burners are located, the combustion chamber is 100 per cent water-cooled.) The results of the test were that, when Ruhr coal with as low as eight per cent volatile was fired, satisfactory combustion was impossible without a return bend flame; however, after that coal had been mixed with high-volatile Upper Silesian coal, to bring the total volatile up to 15 per cent, it was possible to maintain satisfactory operation even down to partial loads as low as one-fifth of normal.

New Benson Boiler at Langerbrugge

About a year ago another Benson boiler was ordered by Mr. Herry, President of the "Centrales électriques des Flandres et du Brabant" for its famous high-pressure pioneering station at Langerbrugge, Belgium. The normal capacity of this boiler will be 220,000 lb. per hr., the maximum capacity 300,000 lb. per hr., i. e., three times as much as the second unit of the cableworks.

At Langerbrugge the Benson plant will be superimposed, so to say, on the existing 800-lb. system of that plant. The design of the boiler is almost the same as that of No. 2 unit of the cableworks. The burners are primarily destined to burn powdered coal, but provision is made also for oil and gas firing.

No main super-pressure turbo-generator will be superimposed to the existing 800-lb. turbines, until additional Benson boilers will be installed. High-pressure steam from the first Benson unit, however, will expand in an auxiliary turbine to drive the feed pump. Steam will enter this turbine ungoverned after having passed through the overflow valve which maintains the critical pressure. The back pressure will adjust itself according to the pressure in the 800-lb. main and to the frictional pressure drop in the Benson superheater.

On the same gear as feed pump and pump turbine are connected to, there will be an induction motor to maintain constant speed. It will work as a motor as long as the feed pump work is higher than the work delivered by the steam to the turbine, and it will work as generator as soon as the power of the turbine is in excess of what is required of the feed pump. The boiler plant is now nearing completion and will be ready for operation early this summer.

Oil and Gas Power Division, A.S.M.E. Meets at Penn State

Third National Meeting of the Oil and Gas Power Division of the A.S.M.E. and Fourth Annual Penn State Oil Power Conference will be held at State College, Pa., June 12, 13 and 14. The technical program this year will occupy five sessions. Because of the number of papers, all authors will abstract their papers to present them in about fifteen minutes and to allow time for discussion.

At the opening session on Thursday the papers to be presented are on research and the rest of the program, to a certain extent, is built upon it. The afternoon session will include two reports on Fuel Oil Specifications and Cost Data which are foundation work for future progress. Superchargers and lubrication are the other subjects for this session.

Friday morning session is on power plant economy and layout and on Saturday morning there will be papers on recent metallurgical advances, lightweight Diesel design and elimination of torsional vibration. On Saturday afternoon, natural gas developments, the oil engine in aeronautics and Diesel engine tractor and excavator, will be discussed. On Thursday afternoon there will be a card party and dance; on Friday, mountain excursion or golf, with banquet and dancing in the evening, and a full program of entertainment for the ladies. E. J. Kates, 570 Seventh Ave., New York, is in charge of sleeper arrangements and reservations should be made through him. Arrangements are being made by the Housing and Registration Committee at Penn State to accommodate 400 visitors in the new dormitories and dining room.

Burning of Small Particles of Carbon

A large amount of information on the manner in which small particles of carbon burn has been obtained as the result of tests conducted at the Pittsburgh Experiment Station of the United States Bureau of Mines, Department of Commerce. It has been found possible, by a novel method, to determine accurately the rate at which such particles of different sizes burn in air at different particle surface temperatures and at a wide variety of air velocities. In all cases the specific-surface reaction rate increases with increasing particle surface temperature. This temperature coefficient is enormously larger for the smaller particles than for the larger particles. Also, the specific-surface reaction rate is much larger for the smaller particles than for the larger particles. The rate, of course, increases with increasing air velocity. The results are of especial interest in connection with the design and operation of furnaces burning powdered fuel.

Boiler Feedwater Purification Methods

CONTINUOUS AND INTERMITTENT PRECIPITATION WATER SOFTENERS AND ZEOLITE SOFTENERS. TYPES, METHODS OF CONTROL AND OPERATION. BY H. A. KULJIAN.[1] PART II[2]

PRECIPITATION water softeners embody the main principle of adding prescribed amounts of definite soluble chemicals, usually lime and soda ash, to react with the hardening compounds of the raw water.

There are two main divisions of precipitation plants, namely, intermittent and continuous. The former consists of two or more settling tanks, one filling and receiving its charge of chemicals, while the other tank is being used to deliver treated water to service. In this way each tank goes through a cycle of operations; filling, charging, agitating, quiescent settling and finally emptying. Continuous plants usually have one settling

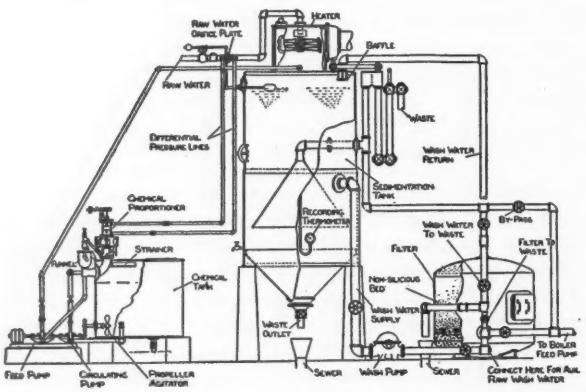


FIG. 2. TYPICAL HOT PROCESS WATER SOFTENER

tank, and the water flows continuously from inlet to outlet, receiving the charge at the inlet of the mixing chamber of the reaction tank and settling as it flows through. Filter usually follows in each case.

Intermittent plants are preferred for the treatment of waters which vary considerably in composition because the average composition of each tankful of water can be determined and the required treatment calculated.

Some continuous plants have heaters ahead of the settling tanks and permit the reactions and settling to take place at boiling temperature. Although this gives a resulting effluent of lower hardness and a smaller settling tank is permissible because of more rapid reactions, the loss of heat by radiation from the settling tanks and filters and loss of hot water in sludging of the settling tank and washing of filters must be considered. This loss is considerable if the heater shell is left without covering. This can be almost eliminated simply by insulating the shell with asbestos or magnesia.

OPERATION OF PRECIPITATION WATER-SOFTENER PLANTS

In the operation of precipitation plants, it is necessary to make a chemical analysis of the raw water to calculate the correct charge of lime and soda ash or other reagents to react with the varying composition of the raw water. Many water supplies are drawn from surface sources such as rivers or ponds. Sudden storms will change the mineral content of a stream completely in a few hours. If too little chemical is added, the water is under treated, and if too much chemical is added, over treatment results. The addition of too great an excess of lime may give a water even more objectionable than the original supply, since lime, besides being caustic, is also a form of hardness. The operator must be alert and skilled to control the treatment properly.

Besides the need of skilled supervision to apportion the chemical dosage to suit the composition of the raw water, there are various mechanical problems to solve. Sludge disposal from the settling tanks frequently clogs sewers and some city ordinances prohibit dumping sludge into sewers on this account. This frequently entails sludge collection in pits and removal by digging out and carting away to disposal dumps. The mechanical problem also exists of feeding the chemicals at a rate in proportion to the rate of the raw water flow. Since the chemicals are usually fed in the liquid or suspension form, or a milk, the proportioning device may become coated with the lime, with the resultant change in the rate of chemical dosage. The complexity of this chemical feed problem from the mechanical point of view is evidenced by the hundreds of devices that have been developed and patented to show chemical reactions.

Most of these chemical proportioners accomplish their purpose to a greater or lesser extent. The principal difference is in the mechanical design and as a consequence some are better than others. Tilting bucket type proportioners are common on cold water softening processes. One manufacturer has developed a control chart for the operation of water softeners, the operating principle of which is as follows: This consists of simple tests with a standardized solution of sulphuric acid with the aid of an indicator. The common indicators which are used are phenolphthalein and methyl orange.

In testing the treated water, a sample is taken and a few drops of phenolphthalein indicator placed in it. If the water is properly treated, it should turn pink. The standard acid solution is added until the color in the sample is destroyed. The quantity of acid used gives what is called the Ph. or hydrogen ion reading. Then methyl orange, another indicator, is added to the sample and additional acid is added until the sample turns from yellow to orange. The total amount of acid required gives the methyl orange reading. On a chart, these two readings are intersected and the proper change in treatment, if one is required, is indicated. If the treatment is correct, that is also shown.

Equations in the table show practically all the chemi-

[1]Eng. in charge of Power Div., The Viscose Co., Marcus Hook, Pa.
[2]Part I appeared on page 548 of the May 15, 1930 issue.

cal reactions that take place in either hot or cold process of water softening.

To reduce the hardness of water in question, an excess amount of chemicals are to be added to get the desired amount of reduction of hardness. It is considered that 1 to 1.5 gr. per gal. of impurities in purified water are considered suitable for steam generation. To get this, 1.25 to 1.5 gr. of excess soda (in terms of sodium carbonate) is to be used.

Chemical reactions take place more rapidly in hot process than cold and since most plants are using continuous process of softening, the time element is vital for the reduction of impurities. This could be reduced to its minimum of 8 to 10 minutes at a temperature of 205 to 210 deg. F.; however, the retention period of the settling tank should be not less than one hour.

This method is recommended only for water containing a high percentage of sodium carbonate salts in water with very small amount of sulphates and chlorides of sodium.

The following equation shows the chemical reaction:

$$Na_2CO_3 + H_2SO_4 - NA_2SO_4 + H_2CO_3$$
$$H_2CO_3 + \text{Heat} - H_2O + CO_2$$

Sodium carbonate (Na_2CO_3) is changed to sodium sulphate (Na_2SO_4) and carbonic acid (H_2CO_3), the latter can be driven out of the heater by increasing the temperature of water a little above 212 deg. F. This is done merely to prevent sodium carbonate breaking into sodium hydroxide and carbon dioxide.

$$Na_2CO_3 + H_2O - 2NaOH + CO_2$$

If this sulphuric acid feed is used, precaution should be taken always to under-feed the acid, and take care of the remainder of Na_2CO_3, by feeding proper amount of Na_2SO_4, so that the ratio of Na_2SO_4 to Na_2SO_3 will be approximately equal to .014 $\times$ Boiler Pressure.

Tri-sodium phosphate method of treatment has been tried in place of soda ash with the understanding that calcium and magnesium phosphates would cause less priming in boilers than calcium carbonate and magnesium hydrate, which would be present in water after the treatment of soda ash method.

$$3CaCO_3 + 2Na_2PO_4 - Ca_3(PO_4)_2 + 3Na_2CO_3$$
$$Na_2CO_3 + H_2O - 2NaOH + CO_2$$

Soda ash and sodium silicate are generally used as boiler compounds, because the initial cost of ordinary softening plants is too great for small plants. If some of these chemicals are used in excess, they will also form scale. They are to be used just in sufficient amount to replace all scale forming impurities.

Zeolite Water Softeners

Zeolite plants accomplish the removal of the hardness by simple filtration of the water through a bed of zeolite material suitably supported and distributed in a container with piping and valves attached to distribute and control properly the flow of water. The hardness is removed from the water by the well-known base exchange principle, the zeolite exchanging its sodium base for the calcium and magnesium bases in the water. A meter is provided to indicate when the softener has passed the quantity of water it was designed to soften.

The zeolite bed is then automatically regenerated or revivified by passing a solution of salt (common brine) through the softener. The brine, by a reverse exchange reaction, gives its sodium base to the zeolite, and as it leaves the softener it carries with it in a clear solution the calcium and magnesium extracted from the zeolite. The zeolite is then rinsed free of brine and the softener is again thrown into service by opening the necessary valves.

On passing hard water containing either temporary (carbonate) or permanent (sulphate or chloride) hardness through a bed of zeolites, the hardness is removed according to the following reactions in which Ze represents zeolites.

$$Na_2\ Ze + CaSO_4 = Na_2SO_4 + Ca\ Ze$$
$$Na_2\ Ze + Ca(HCO_3)_2 = Ca\ Ze + 2Na_2(HCO_3)_2$$
$$Na_2\ Ze + CaCO_3 = Na_2\ CO_3 + Ca\ Ze$$
$$Na_2\ Ze + MgSO_4 = Mg\ Ze + Na_2SO_4$$
$$Na_2\ Ze + Mg(HCO_3)_2 = Mg\ Ze + Na_2(HCO_3)_2$$

and when it is regenerated by passing salt solution through the material:

$$Ca\ Ze + 2\ NaCl = Na_2\ Ze + CaCl_2$$
$$Mg\ Ze + 2\ NaCl = Na_2\ Ze + MgCl_2$$

REACTIONS WHICH TAKE PLACE IN BOTH HOT OR COLD PROCESS SOFTENER

IMPURITIES	CHEMICAL REACTORS	IMPURITIES		REMARKS
		SOLUBLE	INSOLUBLE	
$Ca(HCO_3)_2$	$Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow 2CaCO_3 + 2H_2O$	2GR. GAL. 5GR. GAL.	$CaCO_3$	ORDINARILY USED QUICK METHOD
$Ca(HCO_3)_2$	$Ca(HCO_3)_2 + HEAT \rightarrow CaCO_3 + H_2O + CO_2$		$CaCO_3$	
$CaCO_3$			$CaCO_3$	
$CaSO_4$	$CaSO_4 + Na_2CO_3 \rightarrow CaCO_3 + Na_2SO_4$	Na_2SO_4	$CaCO_3$	FORMS SOFT SCALE
$CaCl_2$	$CaCl_2 + Na_2CO_3 \rightarrow CaCO_3 + 2NaCl$	NaCl	$CaCO_3$	
$Mg(HCO_3)$	$Mg(HCO_3) + HEAT \rightarrow MgCO_3 + CO_2 + H_2O$ $Mg(HCO_3) + 2Ca(OH)_2 \rightarrow 2CaCO_3 + Mg(OH)_2 + 2H_2O$	$MgCO_3$	$Mg(OH)_2$ & $CaCO_3$	
$MgCO_3$	$MgCO_3 + Ca(OH)_2 \rightarrow CaCO_3 + Mg(OH)_2$	Na_2CO_3	$Mg(OH)_2$	
$MgSO_4$	$MgSO_4 + Ca(OH)_2 \rightarrow Mg(OH)_2 + CaSO_4$ $MgSO_4 + 2NaOH \rightarrow Mg(OH)_2 + Na_2SO_4$	Na_2SO_4	$Mg(OH)_2$	
$MgCl_2$	$MgCl_2 + Ca(OH)_2 \rightarrow Mg(OH)_2 + CaCl_2$	$CaCl_2$	$Mg(OH)_2$	
$Na(HCO_3)$	$2Na(HCO_3) + HEAT \rightarrow Na_2CO_3 + CO_2 + H_2O$ $2\ NaHCO_3 + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O + 2CO_2$			
Na_2CO_3		Na_2CO_3		
Na_2SO_4		Na_2SO_4		
NaCl		NaCl		
Al_2O_3		Al_2O_3		GEN-REMOVED BY FILTER
Si_2O_3			Si_2O_3	" "
FE_2O_3			FE_2O_3	

The chlorides of calcium (Ca) and magnesium (Mg) are discharged to the sewer in clear solution.

Zeolites Classified by Physical Structure

Different types of zeolites vary in their softening capacity, the time required completely to exhaust and completely to regenerate them, and the amount of salt required to regenerate them. To explain these differences, the zeolites used today may be classified for practical purposes on the basis of their physical structure into the following two groups, as porous zeolites, light weight mineral and practically non-porous or solid zeolites which are heavy weight.

Grains of the first group are, as the names implies, filled with minute microscopic holes or passages of capillary proportions. To this first group belong the so-called artificial zeolites whether made by fusing the ingredients together in a typical glass furnace and then hydrating and leaching or whether made by a precipitation process. Whether they contain aluminium or iron as a constituent is of no importance. The so-called

natural zeolites made from clay that is passed through a series of artificial operations, such as grinding, shaping, baking, and hydration, also belong to this porous group.

Grains of the second group are practically non-porous or solid. They are like tiny pebbles, and the contact of the water with this zeolite is practically restricted to their outside surfaces. To this second group belong the zeolites consisting of glauconite.

All zeolites have about the same specific gravity, 2.0 to 2.4 but the zeolites of the first group by reason of their porosity weigh less per cubic foot than the more solid zeolites of the second group. The various porous zeolites when in moist condition weigh from 40 lb. or even less up to 70 lb. per cu. ft., according to their porosity. They contain water up to 50 per cent of the total weight. Non-porous zeolites in the moist condition

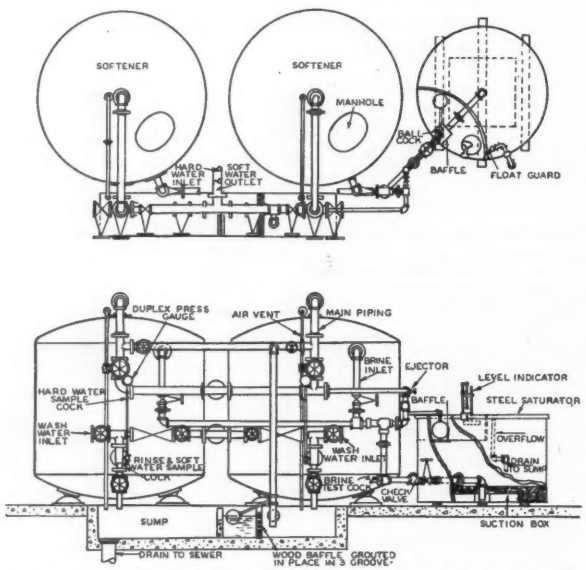


FIG. 3. GENERAL ARRANGEMENT OF A ZEOLITE WATER SOFTENER

weigh about 100 lb. per cu. ft. and about 90 lb. per cu. ft. air dry.

Base Exchange Power Between Regenerations

The base exchange power between regenerations means the total number of grains of hardness, usually expressed as calcium carbonate, which a cubic foot of zeolite absorbs or exchanges up to the point when zero hardness water is no longer produced. This may be called the softening capacity of the zeolite and must not be confused with the total exchange power. The function of the zeolite softener is to produce nothing but zero hardness water. After this point is passed, the zeolite still has base-exchange power left and considerable additional water can pass through in a partially softened condition before the water emerges with the same hardness with which it entered.

This base-exchange power or water softening capacity is directly proportionate to the active surface of the zeolite. Since the porous zeolites have an active interior as well as an exterior surface, it would naturally be expected to have greater water softening capacity than the solid zeolites.

Softening capacity of a practically non-porous zeolite of about ½ mm. grain size is about 2500 to 3000 gr. as $CaCO_3$ per cubic foot and with increasing porosity the capacity of the porous zeolite increases to 10,000 gr. as $CaCO_3$ per cubic foot and higher. This means from the theoretical point of view that the amount of non-porous solid zeolites must be larger if they are expected to do the same work between regenerations as the porous ones, assuming that the porous mineral retains its exchange power.

Rate of Softening and Rate of Regeneration

Internal surfaces of the porous grains are harder to reach than the external surfaces of the solid granules. To pass the liquid over the external surfaces takes comparatively little time. This holds true with the water softening reaction as well as the regeneration. Thus the solid zeolites and the outside surfaces of the porous zeolites can be regenerated in 20 to 30 min. whereas the interior surfaces of the porous zeolites may require one or more hours.

Porous zeolites are usually larger in grain size than the non-porous zeolites. This gives the latter somewhat more external surface area for the same volume of material. The smaller a sphere is the greater is the ratio of its surface area to its volume. But if the porous zeolites are reduced to the same grain size as the solid zeolite and only the external surfaces are called into action, both types of zeolites will act at the same rate and produce that amount of soft water which corresponds to their exterior surfaces. The difficulty in bringing the liquid in contact with interior surfaces causes the delay in utilizing them.

Generally speaking, it is not the stuff of which the solid zeolite is made or the way it is processed which makes it a rapid-rate material, it is merely the physical arrangement of the active reacting surfaces on the outside of the grain.

Salt Requirements

More time and brine are required for regeneration of porous zeolite, because of the difficulty of reaching the inner parts of the grains.

In general, the porous zeolites are used advantageously for hard, perfectly, clear waters, free of iron. Such water is seldom found. It is essential that the porous zeolites receive clear water, free of iron and organic matter, because the inner passages must be kept clean and accessible. Mud, suspended matter, iron, etc., would clog these passages up and then the porous zeolite would become inactive.

Solid zeolites are adapted to all waters, even those that are not crystal clear, such as the filtered river and lake waters. These zeolites can handle slight amounts of turbidity without loss of efficiency if sufficiently backwashed after each softening run and only require clarifying filters to precede them if the hard water is turbid continuously.

Feedwater purification is a chemical problem and therefore the selection of equipment for such a plant should be analyzed from that point of view. The water in question should be analyzed thoroughly and then the decision made as to which kind of a purification plant will work the best. It may be a soda-lime process, the zeolite process, or a combination of the two.

The Field for

Air-Cooled Refractory Furnaces

BY ROBERT C. DENNY

Consulting Engineer
M. H. Detrick Co.

MODERATE COST, EFFECTIVE COOLING AND ADAPTABILITY TO EXTENDED FURNACE WALL AREA CHIEF POINTS OF MERIT OF AIR-COOLED FURNACE WALLS

REFRACTORIES will continue to be used for lining the majority of furnaces simply because they are cheap. They possess this economic fundamental but they are also good, that is, good for low maintenance and high efficiency under severe operating conditions, provided they are correctly applied. The modern method for using refractories in wall construction constitutes an art in itself, with its history of failures and successes, with its well developed technique and with its specialties in design and application.

Air-cooling of furnace refractories lengthens their period of usefulness under practical furnace conditions. The carrying away of heat by air streams at the back faces of air-cooled refractories keeps the temperature at their fire faces below that at which vitrification and erosion take place. This temperature reduction is in the refractory itself and permits higher furnace temperatures without affecting the wall structure. Low maintenance follows as a direct physical result and high efficiency as an indirect result following the allowable high CO_2 content of the flue gases.

There is no real conflict between the systems of solid brick work, air-cooled refractory linings and boiler tube heat absorbing surface, for furnace construction. The problem of which to use can always be solved by common calculation of the costs and economies of each. Proponents of each type are not likely to undertake responsibility for their favorite system in cases where their own sound sense and experience indicates probable engineering failure.

Solid brick walls are unquestionably economical for small furnaces operated at low duty and where simplicity in construction must be obtained with a minimum of investment. The general use, in a plain wall, of higher grade of refractories than, or of substitutes for, standard firebrick immediately lifts the problem from the low-cost region into economic comparison with other wall construction. If the special materials are for small localized areas, such as along the fire line of stokers, there may not be sufficient increase in cost to require this economic comparison.

For the huge steam generating units of modern central stations, operating in the region of 300 to 500 per cent rating, and involving a heat release in the furnace of 30,000 B.t.u. per cubic foot, no refractory engineer will advocate his materials as primary furnace lining. This is the place for water walls, with refractories used as the secondary lining. Such water walls cost several times as much as refractory walls, but their cost is justified in view of space values and additional heat absorbing surfaces.

Refractory specialists do not labor under any illusion as to the practicability of high-grade combustion in a completely metal-lined furnace, for certain methods of fuel firing. The cast-iron house heating furnace and

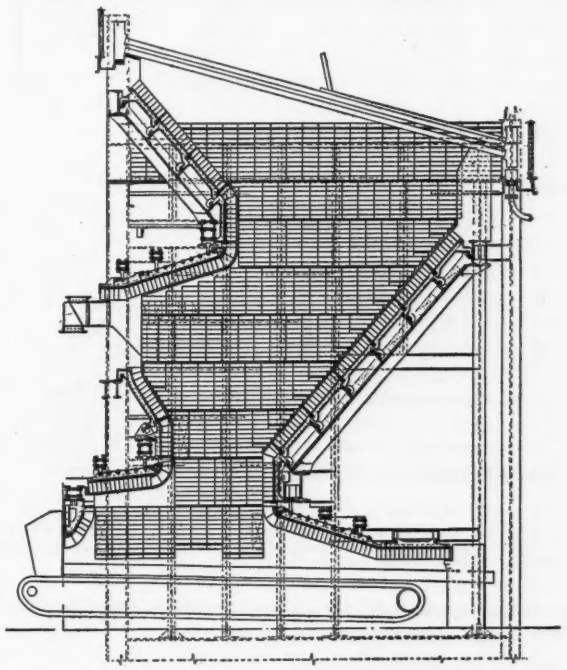


FIG. 1. AIR-COOLED, SECTIONALLY SUPPORTED, REFRACTORY FURNACE FOR A 640-HP. BOILER FIRED BY A 209-SQ. FT. CHAIN GRATE STOKER

The stoker fuel is coke breeze and the burner is for blast furnace gas. Furnace is designed for either separate or simultaneous firing of the two fuels. Setting height to bottom of boiler uptake header from floor is about 33 ft.

the standard internal furnace of Scotch marine boilers furnish primary evidence that can be set alongside of the igloo of the Eskimo and his fire surrounded by ice. Of course, these are overfeed fires. Pulverized fuel firing has definitely surmounted the necessity for hot refractory surface as an aid to satisfactory combustion. For stoker furnaces the degree of permissible non-refractory wall surface varies.

In both pulverized fuel furnaces and stoker furnaces it is always possible to design satisfactory refractory walls, so that when water cooling is considered, economic comparisons must be carefully made with air-cooled refractories, so as to determine which will yield the lower cost of steam produced.

In the wide spread between the two extremes of small and large furnaces, the moderate cost of air-cooled

refractory walls is often the deciding economic factor. The large number of air-cooled furnace installations made during the past six years is evidence of their practical value. Air-cooled refractory walls constitute a furnace construction system, which, correctly designed, is substantially permanent; that is to say, the average

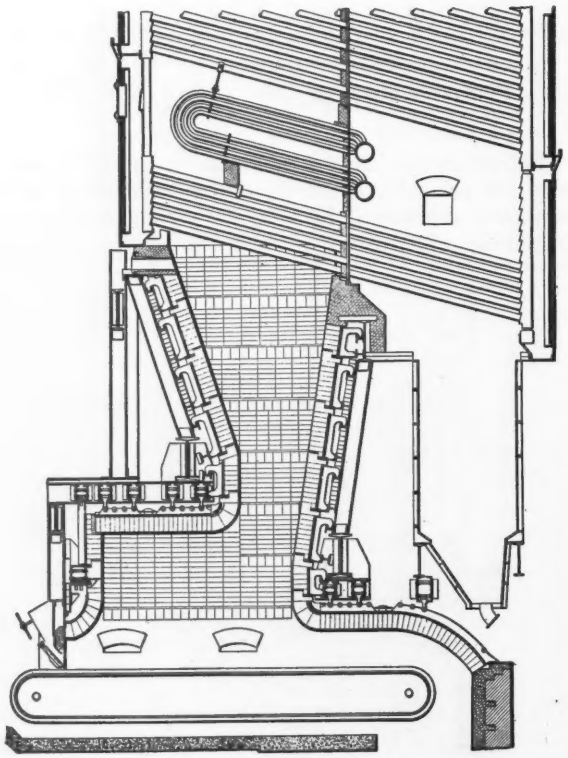


FIG. 2. AN ANTHRACITE BURNING INSTALLATION
This consists of a 1985-hp. boiler, with 364-sq. ft. twin-set traveling grate stokers, and an air cooled, sectionally supported, refractory furnace.

maintenance is well within the practical limits of modern plant economy.

Flames Should Not Sweep the Walls

To secure this economic value for air-cooled walls, it is necessary to observe a number of rational limitations. For pulverized fuel installations, it is well to limit such construction to furnaces where the heat release is not over about 20,000 B.t.u. per cu.ft. per hr. and it is well to locate the walls so as to avoid direct scrubbing by the flame although for stoker furnaces this element of the problem is much less prominent. It is necessary to use the sectionally supported system of wall construction with the steel structure that supports the wall completely outside of the refractories, the air passages, and the outer insulating panelling. Air passages must be adequate for the flow of such quantities of air as are required for the furnace conditions to be obtained. Refractories must be high grade and expansion must be taken care of within the wall itself.

With these necessary factors adequately worked into the design of the wall, such complicated furnace design as shown in Fig. 1 is entirely practical. This furnace is for a chain grate stoker burning coke breeze and blast furnace gas. The space requirements of the problem led to the particular arrangement shown and the furnace duty dictated the use of air-cooled refractory wall structure for maximum economy. The furnace in Fig. 2 is further evidence along this line, and is for a stoker burning anthracite.

The application of this type of wall to large pulverized fuel furnaces, is shown in Fig. 3 and illustrated by Fig. 4, which is a photograph of another furnace. In both of these cases, economy dictated the use of the refractory wall. In both cases, now several years old, operation has demonstrated the soundness of the original analysis.

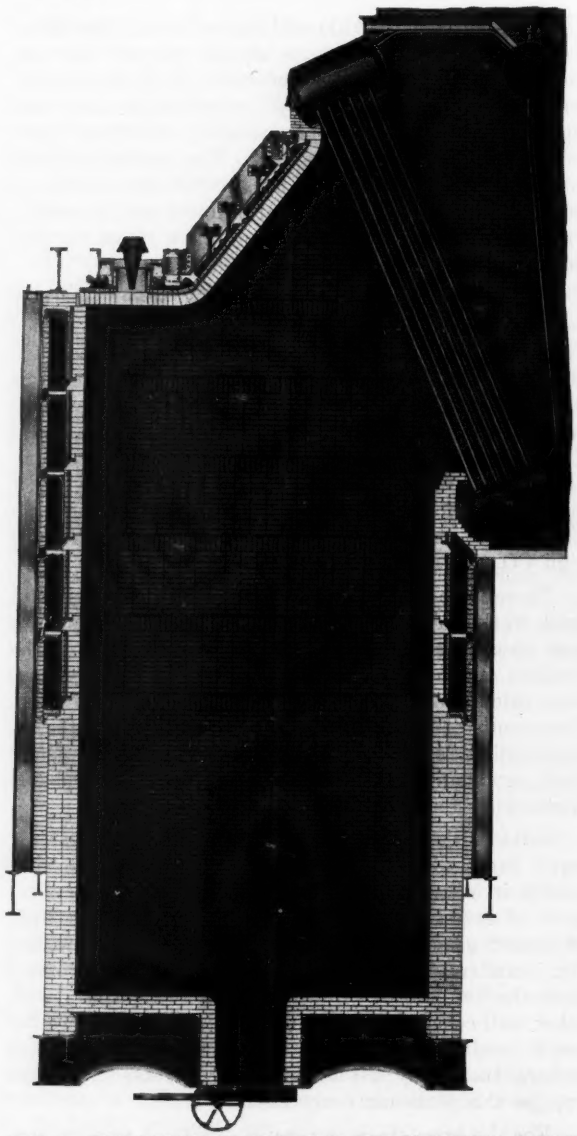


FIG. 3. THE FURNACE SHOWN IS FOR VERTICAL FIRING OF PULVERIZED FUEL FOR A 1200-HP. BOILER
This is a pioneer installation of air-cooled, sectionally supported, refractory construction for furnace walls.

Practical economy should not be confused by incorrect calculation. There is a tendency in this direction that should be corrected. Air-cooled walls commonly return the heated air to the furnace. The tendency is to calculate this heat return as a saving, which it is not. The amount may be several per cent of the total heat

available in the fuel. But it is not a saving because it is merely an internal cycle of heat flow. It does not necessarily reduce the exit temperature of gases from the unit. The real saving by the use of air-cooled walls is simply in the lower amount of heat radiated to the room from the outside of the furnace structure. This is usually not more than one per cent saving over the solid walls with which comparison is usually made.

Reference may be made to one other concept of this nature. It is often rather loosely considered that water walls will inevitably increase the capacity of a boiler unit, and behind this lies the thought that merely adding heat absorbing surface must necessarily increase the heat absorbed.

If the water wall will enable the economical combustion of an increased quantity of fuel, then an increase in economical steam production may follow. This is actually the case in certain combinations of equipment. But if no more fuel can be burned, due to water walls, then it is quite unlikely that any material increase in capacity will result.

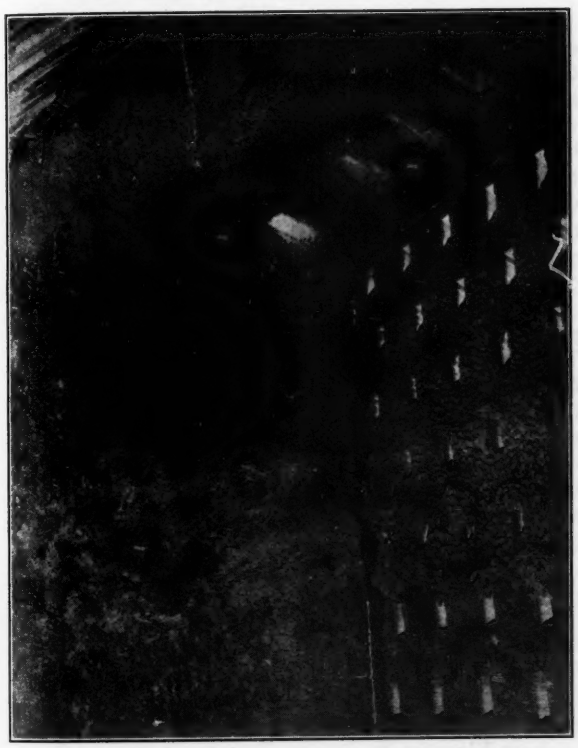


FIG. 4. A PHOTOGRAPH OF THE INTERIOR OF A PULVERIZED COAL FURNACE

This is an air-cooled, sectionally supported, refractory furnace serving a 3060-hp. boiler and vertically fired with pulverized coal. Note the small amount of slag deposits and the excellent condition of the air-cooled, refractory tile.

Of course, no mechanism nor structure is a cure-all. Each has its definite field and its limitations. The refractory furnace wall, even when air cooled and sectionally supported, is no exception. Its deserved popularity for its field of application is harmed, not helped, by exaggerated claims and by erroneous notions of its function. Its moderate cost, its effective air cooling, and its adaptability to extended furnace wall areas, are its chief points of merit. Advances in the legitimate field of its application are constantly being made, and modifications for application to wider fields are always under way. It will persist as an important element of boiler plant design only because of genuine economic demand for its use.

Program for A.S.M.E. Spring Meeting June 9-12

TENTATIVE PROGRAM for the semi-annual meeting of the American Society of Mechanical Engineers has been announced. This meeting is to be held at the Book-Cadillac Hotel, Detroit, Mich., June 9-12. Fourteen technical sessions will be held, of which five will be devoted to subjects in the power field. On Monday morning, June 9, a public hearing will be held on a Test Code for Complete Steam-Electric Power Plants. The Power Test Codes Committee hopes to receive comment on the tentative draft of its code and hopes that all interested will submit criticism at the hearing or send written opinions to C. B. LePage, secretary of the committee, at A.S.M.E. headquarters, 29 West 39th St., New York.

On Monday afternoon, a session will be devoted to boiler feedwater studies. Papers will be presented on Electric Conductance Measurements of Water and Steam and Application in Steam Plants by Max Hecht and D. S. McKinney, and on Fractures in Boiler Plates by A. E. White and R. Schneidewind. The industrial power session on Tuesday morning will include papers on Tests of the Resistance of Forged, Riveted and Welded Boiler Shells to Repeated Pressure by H. F. Moore and Boiler Settings for Burning Refuse Wood by Charles S. Gladden.

Wednesday morning at the fuel and power session, William O. Renkin will present a paper on the Dry Quenching of Coke. J. W. Mackenzie will have a paper on Recovery of Fly Ash from Pulverized Fuel Stacks by Use of Stack Sprays. Papers scheduled for the central station power session on Thursday morning include Comparative Performance of a Large Boiler Using Oil and Natural Gas Fuels by Frank G. Philo and Comparative Performance of a Pulverized-Fuel-Fired Boiler Using Bin System and Unit System of Firing by A. E. Grunert. Other meetings will be devoted to applied mechanics, machine shop practice, properties of metals at high temperatures, various industry management, aeronautics and education.

The program includes an array of entertainment features, with a reception and dance on Monday evening, inspection trips, a smoker for the men, and a bridge party for the ladies on Tuesday afternoon; boat trips on the river and an inspection trip to the Ford airport at Grosse Isle Airport. C. F. Hirshfeld is in charge of the technical program, W. P. Thomas is in charge of transportation and H. H. Esselstyn in charge of entertainment. Full details regarding the meeting, as well as transportation can be obtained from the secretary of the A.S.M.E., 29 West 39th St., New York City.

AIR DOES NOT usually contain all the moisture which it can hold, so that it is not saturated. If, however, the temperature should be lowered sufficiently, the same amount of moisture will saturate the air.

Selecting Stokers for New England Fuel

FACTORS IN STOKER, BOILER AND FURNACE DESIGN WHICH ARE IMPORTANT IN MAKING A SUCCESSFUL INSTALLATION. BY R. A. FORESMAN AND DONALD J. MOSSHART*

POWER PLANT INSTALLATIONS differ as to design of equipment, fuel to be burned and the manner in which the equipment is applied so that many factors enter into the selection and design of a successful stoker installation. The problem as found in New England, where the principal fuel is semi-bituminous coal known to the trade as Pocahontas and New River, is here considered in detail particularly in relation to the multiple retort underfeed stoker. This fuel is used almost exclusively and although these are coals highly prized for stoker use, they are more difficult to handle

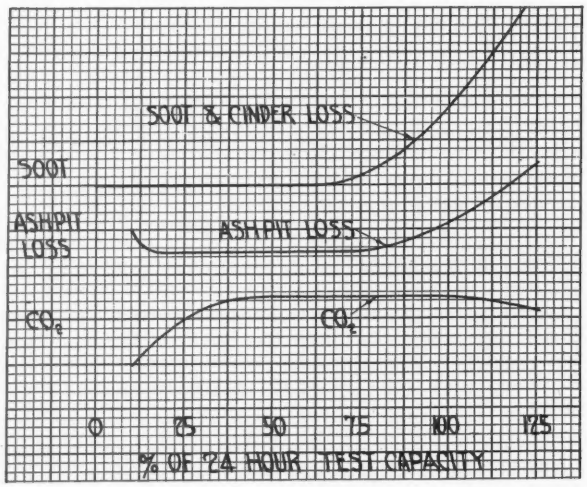


FIG. 1. CHARACTERISTIC PERFORMANCE OF MULTIPLE RETORT UNDERFEED STOKER

than the so-called low grade coals when such factors as stoker maintenance, capacity and flexibility are considered.

Load requirements should be carefully estimated so that the proper size of stoker can be selected. Overloaded stokers are poor investments because of poor performance. Underloaded stokers are poor investments because money is unnecessarily tied up in them. Principal factors in the selection of the size of stoker are the amount and character of the load on the boiler unit, the cost of coal and the evaluation of efficiency and the capabilities of the stoker. The limit of the capacity of the stoker is reached when the fuel bed is blown off the grates. This is a function of the velocity of air through the fuel bed, which, with a given percentage of excess air, is directly proportional to the combustion rate.

We know from physical law that the force of impact of a current of fluid against a stationary object is proportional to the square of its velocity. Therefore, as the combustion rate increases, we might expect the lifting effect of the air current on the fuel bed to increase as the square of the combustion rate, with a consequent sudden and complete blowing of the fire from the stoker. Certain changes, however, take place in the character of the fuel bed, so that the actual area of air passage through the fuel is larger at the higher rates. A compensating reduction in actual velocity through the air passages somewhat modifies the expected action.

METHODS OF RATING STOKERS

Stokers are rated according to their 24-hr. and 4-hr. or 2-hr. capacity. The 24-hr. capacity is that combustion rate just short of where the ash discharge section is smothered with fine coke blown from the fire, or where the blowing is so severe that the fuel bed cannot be maintained in proper condition over a long period of time. The limits of capacity for the shorter periods are of the same nature, the more severe blowing at the maximum rates simply putting the fire out of condition more quickly and limiting the length of time that a given load can be carried.

In the past, stoker capacity has been measured in pounds of coal burned per square foot of grate surface. The amount of air required to burn a pound of coal is a function of the combustible content of the coal, therefore, of the heat content of the coal. In other words, the factor which limits the capacity (the velocity of air through the fuel bed) is a function of the amount of heat being released per unit area and time, rather than of the weight of coal being burned per unit area and time.

This is an important consideration when comparing performance with different coals. The stoker which burns Illinois coal of 10,000 B.t.u. at a maximum rate of 80 lb. per sq. ft., could be expected to fail to burn New River coal of 14,000 B.t.u. at rates above 57 lb. per sq. ft. This comparison is based on equal heat liberating rates.

New River or Pocahontas coal is relatively hard to ignite. Therefore, more of the grate area is inactive with these coals. Equally proficient stokers will be capable of a slightly lower heat liberating rate when burning such coals than when burning high volatile coals. The conclusion is, therefore, that stoker tests should be compared on a basis of heat liberating rate with similar coals.

Characteristic performance in an underfeed stoker is shown in Fig. 1. The abscissae represent percentages of the load that can be carried for 24 hours under test conditions. The ordinates are the three factors in the efficiency of the unit over which the stoker exercises control. Definite values are not assigned, but the different ordinates are of a similar scale of value in per cent overall efficiency of the unit.

Typical load curves of three classes of industries are shown in Fig. 2. On these graphs the blocked figures show the load on the stoker (expressed in per cent of the 24 hour test capacity) for greatest dollar economy, considering investment cost, maintenance and thermal effi-

*Westinghouse Electric & Mfg. Co., So. Philadelphia, Pa. From a paper presented before the A.S.M.E. at Boston, Mass.

ciency under average conditions. Analysis of local conditions, with particular regard to coal cost, may slightly modify these figures. Knowing the capabilities of the stoker, the efficiency of the boiler unit and the load conditions, the selection of the size of the stoker becomes a matter of arithmetic.

Clinker Grinders vs. Dump Grates

In selecting the stoker, the choice between clinker grinders and dump grates must be made. Where the plant carries a fairly heavy load 24 hr. a day, a clinker grinder stoker will ordinarily produce about 2 per cent more in efficiency than a dump grate stoker.

For the load shown at A, Fig. 2, dump grates are the more economical, if the stoker is less than about 14 ft. long. Above that length, clinker grinders should be used because of the large amount of ash to be handled per unit of stoker width. When using stokers of short or moderate length for such loads, the refuse is dumped during light loads or banked periods, and the performance closely approximates that obtained from clinker grinders under similar conditions.

For loads shown at B and C, Fig. 2, clinker grinders should be used for all lengths of stoker, wherever space permits. If space limitations, particularly headroom, prohibit the installation of clinker grinders, dump grates may be installed with the assurance that they will give good results on any length of stoker yet developed.

Preheated Air Does Not Increase Capacity or Efficiency

Preheated air has been in general commercial use for about 4 yr. During this time, extensive study of the problems created and the results obtained by the use of preheated air has permitted the following general conclusions to be drawn:

Improvement in combustion, expected by the sponsors of preheated air and reported as being obtained by many users, has not materialized. Some changes do take place but the beneficial effects, if any, can be duplicated with cold air by proper adjustment of the stoker.

Preheated air does not measurably increase the capacity of the unit. The increased velocity of air through the fuel bed, caused by the greater specific volume of the heated air, increases the blowing of fuel and slightly reduces the coal burning capacity of the stoker. A good rule for commercial practice is to figure a unit of grate area as having a fixed capacity in B.t.u. per hour, the amount of heat admitted to the furnace being the same whether or not the air is preheated.

In the case of cold air, the heat released by combustion is the capacity. In the case of preheated air, the heat released by combustion plus the heat returned by the air is the capacity. In either case, the total heat admitted to the furnace would be the same but with preheated air the amount of coal burned would be less by the coal equivalent of the heat in the air. This rule is not intended as a statement based on tests; it is for the commercial selection of stoker size.

Preheated air does not measurably increase the efficiency of combustion. It may slightly decrease the ash-pit loss, but this is offset by the increased loss in soot or fine carbon carried up the stack. The only value of preheated air lies in the amount of heat recovered and returned to the boiler.

It is more difficult to operate an underfeed stoker with preheated air than with cold air. If the fuel in the retort swells slightly and tends to stick in the retort, as it may easily do with preheated air, any of the various designs of retort mechanisms yet produced lose part of their effectiveness in moving the coal. Readjustment of the motion of secondary pushers or other retort mechanism must be made to compensate for such conditions and when the conditions disappear, further readjustment becomes necessary. Therefore, the amount of operating attention required is considerably increased, particularly where a long retort is used.

The longer the retort, the greater becomes the problem of handling fuel mechanically. Some manufac-

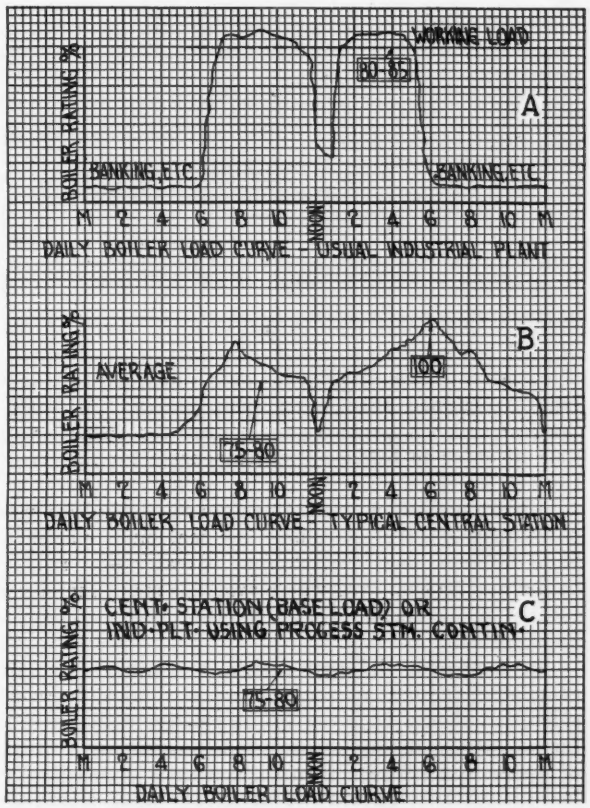

BOILER RATING %
WORKING LOAD
80-85
A
BANKING ETC.
BANKING ETC.
M 2 4 6 8 10 NOON 2 4 6 8 10 M
DAILY BOILER LOAD CURVE USUAL INDUSTRIAL PLANT
BOILER RATING %
AVERAGE
100
B
75-80
M 2 4 6 8 10 NOON 2 4 6 8 10 M
DAILY BOILER LOAD CURVE TYPICAL CENTRAL STATION
BOILER RATING %
CENT. STATION (BASE LOAD) OR
IND. PLT. USING PROCESS STM. CONTIN.
C
75-80
M 2 4 6 8 10 NOON 2 4 6 8 10 M
DAILY BOILER LOAD CURVE

FIG. 2. TYPICAL LOAD CONDITIONS IN THREE TYPES OF PLANTS

turers have limited the length of the retort and are applying a different type of grate surface to complete the stoker to the desired length.

Present day knowledge limits air temperatures to 350 deg. F. for satisfactory operation of a stoker of average length, that is, a stoker with retorts 9 or 10 ft. long, with semi-bituminous coal. It will probably be necessary to make rather radical changes in the basic method of handling fuel, if this limit is to be raised.

There is bound to be some increase of stoker maintenance costs when preheated air is used. Present day knowledge indicates that this increase is small and of lesser magnitude than the variation in costs between different plants operating under similar conditions.

That adequate furnace volume plays an important part in efficient operation has long been recognized. A

number of variant values in the permissible heat release per cubic foot of furnace volume have been advanced. The authors recently assembled for analysis, a large number of tests of stoker fired boilers. It was found that, while the short stokers produced excellent results with surprisingly high heat release per unit of volume, the longer stokers suffered losses from incomplete combustion when operated with the same high heat releases.

This is a perfectly natural condition and is to be expected. The operator is less able to see flaws in the

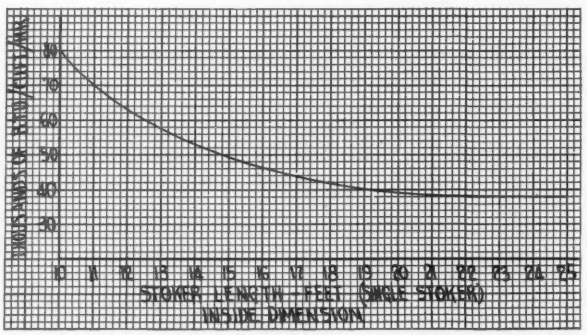


FIG. 3. FURNACE HEAT RELEASE AND MAXIMUM EFFICIENCY IS THE FUNCTION OF STOKER LENGTH

fire of a long stoker than in that of a short one. Areas of fuel bed of too great thickness may go undetected. The control of fuel distribution over a long stoker is less readily obtained than on a short stoker. All these factors render it necessary to increase the furnace volume in order to balance and compensate for imperfections in the fire.

Figure 3 shows a graph of values of heat release per cubic foot of furnace volume for maximum efficiency with different lengths of stokers. Greater heat release values may be employed where available space limits the volume of the furnace, but a lowered efficiency should be expected.

In comparing different designs of furnaces, and in calculating the heat release per unit of volume, due consideration should be given to the relative value of different sections of the furnace. It is possible to put a lot of useless space into a furnace, and show a deceptively low rate of heat release. Heat release rates should be compared on a basis of useful volume.

Much has been claimed for the use of water-cooled furnace walls. These claims have included reduction of furnace maintenance, reduction of stoker maintenance, increased heat absorption with consequent lower flue gas temperatures, reduction of clinker trouble, reduction of radiation losses and increase of stoker capacity. The authors have not seen conclusive and authoritative figures, which place definite values on these various claims but observation of various water wall applications prompts the following statements:

Water Walls

Water-walls are a valuable aid to the stoker when they provide a clinker-proof wall at the edges of the fuel bed. Aside from this, they are of no value to the stoker burning semi-bituminous coal.

The rear wall of the furnace should receive first consideration in the application of water-walls. Insurance against freezing-over of the ash discharge section is the most valuable function that a water-wall can perform. Should more extended use of water-walls be justified, they should be installed so as to clinker-proof the sides of the stokers. The authors see no justification for the use of a water-cooled front wall.

Semi-bituminous coal burns best if the furnace temperature is high. Low furnace temperatures tend to increase losses from incomplete combustion of gases and unburned solid particles of fuel carried up the stack. A true measure of this effect has not yet been made available, but there is ample evidence that the tendency exists. Naturally, such effects can be offset by increasing the furnace volume. The authors do not believe that there is any justification for the statement that water-cooled furnace walls permit an increase of the rate of heat liberation per unit of furnace volume; rather, that the reverse is true. For present day practice, therefore, it is our opinion that water-walls should be designed and applied in a manner that will not unduly lower the temperature of the furnace.

Some users have found that the use of water-walls, particularly in applications where the furnace temperature was materially lowered, resulted in decreasing the amount of slag deposited on the lower tubes of the boiler. The authors believe that it is quite possible to do this without seriously affecting combustion, particularly by arranging the water-walls so that they exert a maximum cooling effect on the space just below the boiler and a minimum effect on the space just above the fire.

Ashpits Must Be Sealed

There is only one requirement in ash disposal apparatus, and that is, the ashpit below the stoker must be

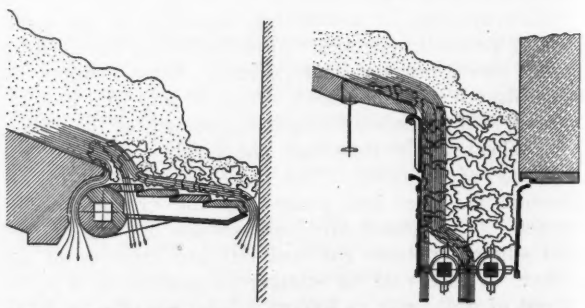


FIG. 4. UNSEALED ASH PITS RESULT IN A FLOW OF AIR AS INDICATED AND CAUSE HIGH MAINTENANCE COST

effectively sealed to hold internal pressure at all times, except for the brief interval necessary for removal of the refuse.

If the ashpit is not sealed, there may frequently be a downward flow of air from the lower end of the stoker through the dump grates or clinker grinder, as shown by Fig. 4. The air may burn enough fuel to raise itself to a temperature high enough to destroy the parts of the ash discharge section. Many cases of high maintenances of dump grates or clinker grinders have been traced to this cause.

For direct-connected motor units, the power input to the driven machine can be calculated from the electrical input to the motor and the motor efficiency.

Electric Boilers Find Wide Use in Industry

IMMERSION TYPE MOST WIDELY USED BUT HORIZONTAL, TUBULAR AND ELECTRODE TYPES USED FOR HIGHER VOLTAGES AND LARGER SIZES

ELECTRIC STEAM BOILERS or generators are becoming of increased importance and are each year playing a more important part in our industrial development. In large sizes, their greatest application comes from the utilization of off peak water power, particularly so, in isolated districts where the market for power sales has not been fully developed. Industrial

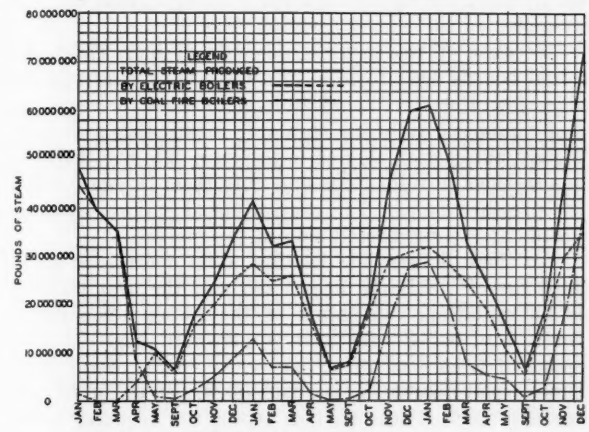

LEGEND
TOTAL STEAM PRODUCED
BY ELECTRIC BOILERS
BY COAL FIRE BOILERS
POUNDS OF STEAM
80 000 000
70 000 000
60 000 000
50 000 000
40 000 000
30 000 000
20 000 000
10 000 000
0
JAN FEB MAR APR MAY SEPT OCT NOV DEC JAN FEB MAR APR MAY SEPT OCT NOV DEC JAN FEB MAR APR MAY SEPT OCT NOV DEC

FIG. 1. COMPARISON OF STEAM PRODUCED BY COAL FIRED AND ELECTRIC BOILERS IN A CENTRAL HEATING DISTRICT OVER A PERIOD OF 3 YR.

applications using purchased power have been in the majority of cases smaller units. Where power is purchased at a fixed price per year and only a portion of it used or where cheap off peak power is available electric steam generators are sometimes justified on an economic basis although in the majority of cases other factors, such as convenience, lower insurance rates, or excessive lengths of steam piping makes the electric unit desirable.

On a thermal basis, electricity is the most expensive form of energy. On a thermal basis electric power at one cent per kilowatt hour and 95 per cent boiler efficiency would cost about $3.07 per million B.t.u., compared with about 27 cents per million B.t.u. for coal and 48 cents per million B.t.u. for oil, assuming coal at $5.00 a ton and oil at 5 cents per gal., figuring 12,500 B.t.u. per lb. of coal and 18,500 B.t.u. per lb. oil running 7.5 lb. per gal., the efficiency in both cases being taken as 75 per cent.

One of the outstanding examples of the use of off peak or surplus water power is furnished by the Winnipeg (Man.) Steam Heating Service. Records plotted in Fig. 1 show that over a period of 3 yr. the electric boilers carried the largest part of the load. This power is generated at the Pointe de Bois plant during off peak periods and was formerly unsalable. It is said that the sale of this power at one-tenth of a cent per kw. earned $65,000.00 during 1926.

Many installations have been made in the paper industry, one of the early installations being in the Gatineau Paper Mill in Canada. This mill had at that time a capacity of 32,000 logs a day with a newsprint machine 256 in. wide operating at a speed of 1200 ft. per min. Electric steam boilers totaling 147,000 kw. were installed in four units, three 42,000 and one 21,000-kw. units. They are connected so that either 25 or 60-cycle power can be used, the boiler being built for 6600-v., 3-phase operation and 200 lb. per sq. in. steam pressure. They deliver steam to an accumulator from which it is drawn at 125 lb. for noncondensing turbines, the exhaust steam being used for drying.

Efficiency of electric boilers is high, the only loss being that due to radiation. This may run from as much as 10 down to as low as two per cent depending upon the covering used. A kilowatt-hour is equal to 3412 B.t.u., while a boiler horsepower is equal to 33,479 B.t.u. At an efficiency of 95 per cent a kilowatt-hour will produce about 3250 B.t.u. or 1 b-hp. would be equal to $\frac{33,479}{3250}$ or 10.34 kw-hr. Roughly. 10 kw. is considered the equivalent of one boiler horsepower and one kilowatt-hour will generate about 3 lb. of steam under

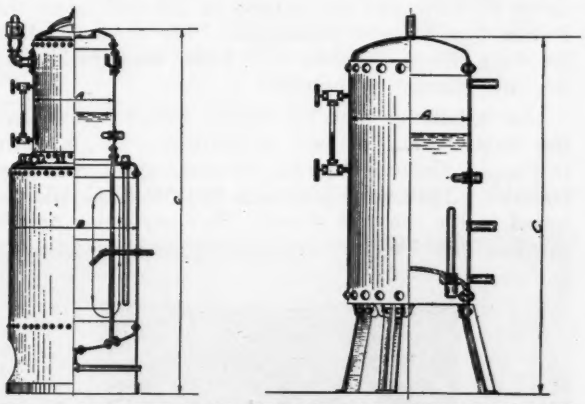


FIG. 2. TWO TYPES OF IMMERSION BOILERS BUILT UP TO 200 KW.

average conditions. Assuming 100 per cent efficiency, the power in kilowatt-hours required to produce 1000 lb. of steam under different conditions is shown in the accompanying table. Approximately the cost of steam in dollars per thousand pounds is 1/3 of the cost of power in mills per kilowatt-hour, thus with power at 9 mills steam would cost 9 × 1/3 or $3.00 per thousand pounds.

IMMERSION TYPE

Three types are in general use, the immersion unit type, such as shown in Fig. 2, being the most common. These are built in units up to about 200 kw., sometimes with the heating element inserted from the top as in 2A, sometimes inserted from the bottom as in 2B and sometimes, in the very small ones, with the heating ele-

ELECTRIC POWER IN KILOWATTS REQUIRED TO PRODUCE 1000 LB. OF STEAM BASED ON 100 PER CENT EFFICIENCY

Lb. Gage Pressure	Initial Feedwater Temperatures, Deg. F. 40	50	60	70	80	90	100	110
0	334.8	331.9	328.9	326.0	323.1	320.2	317.2	314.3
10	337.7	334.7	331.8	328.9	326.0	323.0	320.0	317.2
20	339.6	336.6	333.7	330.8	327.9	324.9	322.0	319.1
30	341.0	338.1	335.1	332.2	329.3	326.3	323.4	320.5
40	342.1	339.2	336.2	333.3	330.4	327.5	324.5	321.6
50	343.0	340.1	337.2	334.2	331.3	328.4	325.4	322.5
60	343.8	340.9	337.9	335.0	332.1	329.2	326.2	323.3
70	344.5	341.5	338.6	335.7	332.7	329.8	326.9	324.0
80	345.0	342.1	339.2	336.3	333.3	330.4	327.5	324.5
90	345.6	342.6	339.7	336.8	333.9	330.9	328.0	325.1
100	346.0	343.1	340.2	337.3	334.3	331.4	328.5	325.5

ments clamped on the outside of the shell. Boilers of this type are built for service up to about 440 v., either single or polyphase, alternating or direct current.

Sometimes the boiler is built integral with the equipment it serves and the unit operates as a closed steam system. If this is impossible, feedwater and pressure regulators can be added to make the unit automatic. Standard equipment includes an automatic control panel, switches, electric heater elements, low water safety element, safety valve, steam gage, water glass, gage cover and blowoff valves. Properly insulated, the efficiency of boilers of this type should be above 90 per cent.

Tubular Type

For the larger sizes and higher voltage, either the horizontal tubular or electrode types are preferred. Below 1500 kw. and for voltages of 550 and below, the former type is more economical. The shells of these units are the well known h.r.t. boiler with the heating elements inserted in the tubes.

An installation used for heating service by the Central Maine Power Company at Lewistown, Me., is shown in Fig. 3. Heating elements are made up of resistance material in flat or ribbon form bent U-shape and inserted in the tubes as shown. This particular unit is rated at 1200 kw. and heating elements are inserted in

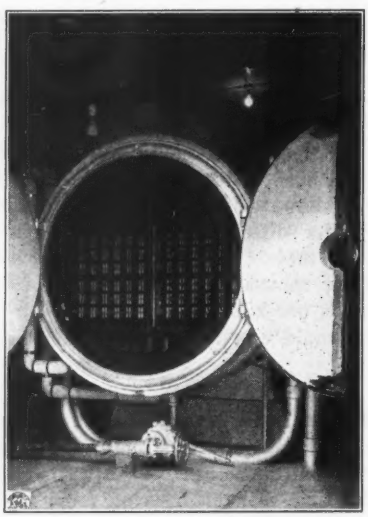


FIG. 3. FRONT VIEW OF THE BOILER INSTALLED BY THE CENTRAL MAINE POWER CO.

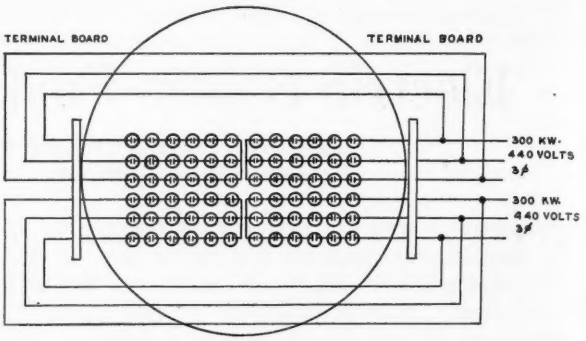


FIG. 4. ELECTRICAL CONNECTIONS OF A TUBULAR TYPE BOILER

each end of the tubes, the control being in four sections as shown in the wiring diagram, Fig. 4.

Because of the heating elements at both ends, terminal boards are provided in duplicate as shown in the side view, Fig. 5. The addition of a feedwater regulator and automatic pressure regulator makes this unit completely automatic. A rise in pressure cuts out the various sections in 5-lb. steps and cuts them in again when the pressure drops. The control board and switches are visible at the right-hand side of the picture.

In these boilers, the heating units operate at about 1400 deg. F., a fairly bright red and the heat transfer is by radiation. Variation of the ribbon temperature for a 3-in. boiler tube unit is shown in Fig. 6 over a range of from 4 to 48 w. per sq. in. energy dissipation. The normal dissipation is about 33 w. per sq. in. of unit surface. Being immersed in water, the adjacent boiler tubes are of course kept close to water temperature.

Electrode Type

For large sizes and high voltages, the electrode type boiler is the most suitable although relatively more expensive. In this type electrodes are immersed, the water itself acting as the resistor. Several designs are available, some of them having electrodes inserted in the base of a cylindrical shell. Electrical input is controlled by raising or lowering vertical tubes around the electrodes.

In this country, the electrodes are usually hung from the top, the electrical input being controlled by varying the water level. A drawing of this type boiler is shown

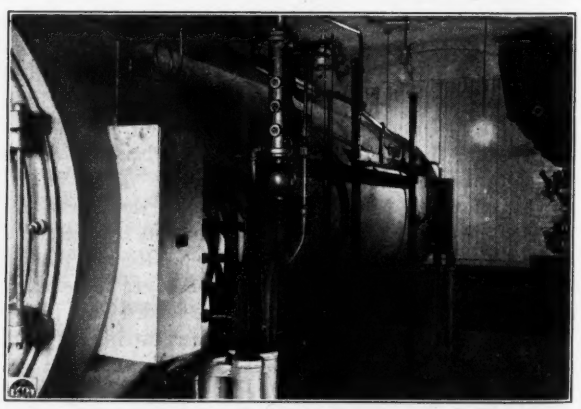


FIG. 5. SIDE VIEW OF A HORIZONTAL TUBULAR INSTALLATION RATED AT 1200 KW.

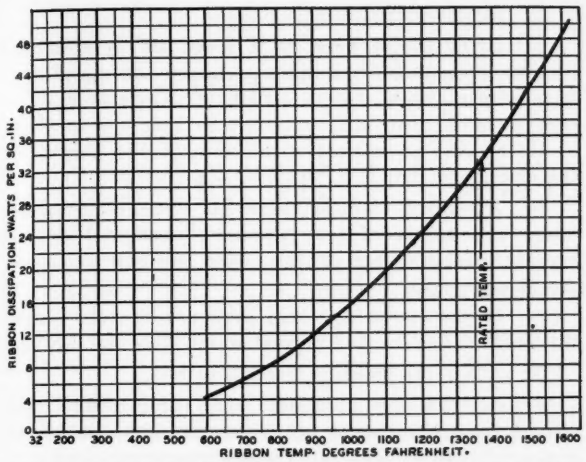


FIG. 6. RELATION BETWEEN ENERGY DISSIPATION AND HEATER ELEMENT TEMPERATURE

in Fig. 7 and an installation at the Wausau Sulphate Fibre Co. in Fig. 8. As shown in the drawing, the shell is divided into three parts, the top or steam space, the bottom or water storage and the middle or basket section which is the active part.

Water is pumped into the basket from the storage space by means of a motor-operated centrifugal pump. Small drain holes in the basket allow the water to flow back to the storage so that a continuous circulation is maintained. In case of failure of the feedwater supply or circulating pump, water drains out of the basket through these holes and the unit goes out of service gradually as the water level drops.

Steam pressure is maintained automatically by a regulator operating the pump valve and so controlling the water level in the basket.

Feedwater has a considerable influence on the operation of electrode boilers because the water itself is used as the electrical resistance and this resistance varies with the chemical content and temperature of the water. Clear river water gives satisfactory operation but if the mineral or chemical content of the water is considerable, treatment may be advisable. Resistance decreases rapidly as the temperature is increased, a certain water with a resistance of 1650 ohms per cu. in. at 70 deg. F. has a resistance of only 410 ohms at 280 deg. F. Treating this water raised the resistance about 250 ohms at 210 deg. F.

When considering the installation of a steam generator, three factors should be taken into account: the necessity for pure or properly treated water; the liberation of some hydrogen which is explosive and must not be allowed to collect in pockets and the cost of auxiliaries, such as relays and transformers.

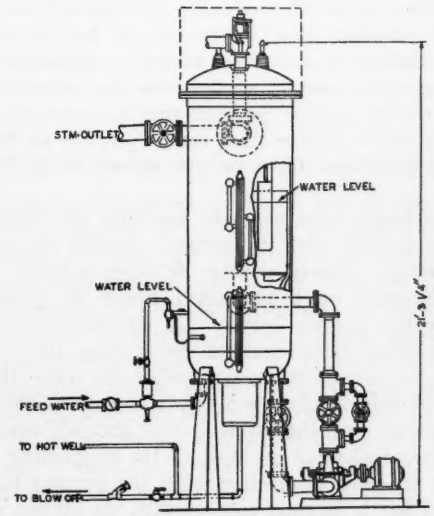


FIG. 7. SECTIONAL VIEW OF AN ELECTRODE BOILER USED FOR LARGE SIZES

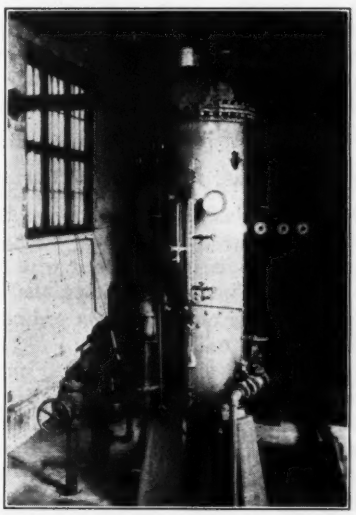
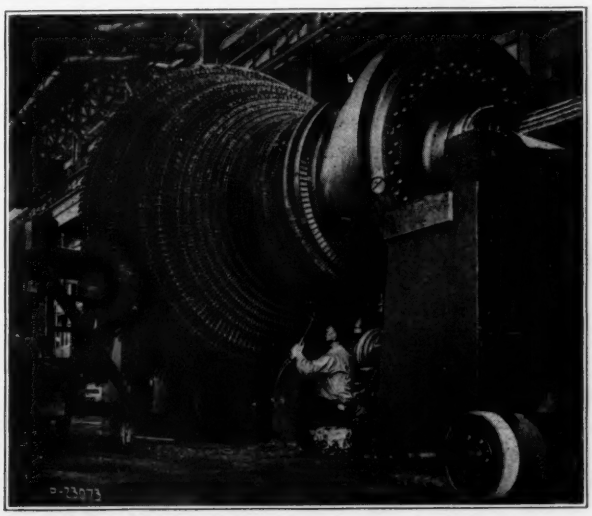


FIG. 8. AN ELECTRODE TYPE BOILER AT THE WAUSAU SULPHATE FIBRE CO. IN WISCONSIN

Manufacturing a Large Turbine Rotor



PUTTING THE FINAL TOUCHES ON A 60-T. TURBINE SPINDLE AT THE SOUTH PHILADELPHIA WORKS OF THE WESTINGHOUSE ELECTRIC & MANUFACTURING CO. THE SPINDLE IS PART OF A 60,000-KW. STEAM TURBINE GENERATOR UNIT WHICH WILL OPERATE AT 1800 R.P.M.

Operating Code Manual for Power Plants

METHODS FOR MAKING TESTS ON TURBINES AS RECOMMENDED BY THE N.E.L.A.

ALL TURBINES are fitted with an overspeed trip or safety device usually set to trip automatically when the turbine reaches a speed of approximately 10 per cent above normal. This safety feature should not be neglected and allowed to become inoperative through neglect. In many plants, the turbines are normally shut down, using the hand trip instead of slowly closing the throttle. In either case, the overspeed trip should be tested periodically as outlined below.

PERIODIC OVERSPEED TESTS OF TURBINES

These tests are to be made under the personal supervision of the shift supervisor.

1. Bring the turbine up to speed with field on the generator. (Note: Time for bringing the machine up to speed should not be changed from ordinary practice for these tests.)

2. See that the machine remains at normal speed under control of the governor.

3. Close the throttle and when the speed of the machine has dropped below normal, make necessary adjustment so that machine will not be under control of the operating governor. (Note: Rule to cover specific equipment and procedure to be made by the constituted authority and inserted here.)

4. Open the throttle and allow the machine to accelerate until the automatic overspeed device operates, and note the speed and frequency at which this takes place.

5. Do not relinquish hand control of the machine until it is certain that the throttle has entirely closed under the action of the automatic overspeed device, as indicated by immediate decrease in speed and first-stage pressure.

6. If the automatic overspeed device does not operate when the overspeed reaches approximately (.....) per cent, trip the throttle by hand, overhaul overspeed mechanism and put in first-class working order, as proved by further tests, before unit is put in service. (Note 1: In case specific practice is to reduce overspeed during these tests by means other than tripping throttle, rule to cover this feature should be made by the constituted authority and inserted here.) (Note 2: Provision should be made for adequately cushioning the throttle valve to prevent excessive wear on the valve seat.)

TEST MADE AT REDUCED SPEED

1. If the turbine has been running, slowly close the throttle valve by hand and allow the turbine to come to rest.

2. Remove the handhole plate on the governor pedestal and place on the emergency trip the weight provided for the purpose. (Note: If the machine has stopped in such a position that the weight cannot be attached, open the throttle sufficiently to turn the turbine shaft, and trip the throttle immediately when the shaft starts to move. Repeat if necessary until machine stops in position where weight may be attached.)

3. Replace the handhole plate.

4. Bring the turbine up to speed slowly and note with tachometer and frequency meter the speed and frequency at which the emergency trip operates. The control mechanism should be set so that the machine would operate at normal speed without the weight on the emergency trip.

5. After the throttle valve has operated properly under the action of the automatic overspeed device, operate the handwheel to the closed position and reset the throttle trip.

6. If the emergency trip does not operate before the machine has reached normal speed, close the throttle.

7. Allow the machine to come to rest.

8. Remove the handhole plate and remove the weight from the emergency trip. Overhaul the mechanism, putting it into satisfactory operating condition, dition, as proved by further tests.

9. When tests are complete, remove the weight and replace the handhole plate.

Care of Switchgear Contacts

BY W. E. WARNER

SURFACES of both the fixed and movable blades on switches and circuit breakers need maintaining in good condition. Dirt and oxide on the contact surfaces cause localized heating which is liable to soften the steel backing springs and the hard brush copper of the laminated brush. Metal polish is excellent for cleaning the metal surfaces of switches and circuit breakers.

In the case of oil switches, the contacts are prevented from oxidizing when working through being immersed in oil but the switch surfaces should be well cleaned before placing in the tank. The intimacy of contact should be checked by means of an 0.002-in. feeler gage with the contacts closed, the gage should not enter between them. The efficiency of contact over the whole surface can be tested by making up a thin mixture of Prussian blue and oil; this should be smeared on the contacts and the switch closed. After this is done, the switch should be opened; any high spots will be plainly visible by the appearance of the film of Prussian blue. These should be rubbed down so that there is good contact over the entire surface.

Finger type contact surfaces can be ground in with a mixture of pumice powder and oil; this is a good abrasive and is better than emery powder as it is not so hard and less liable to get embedded in the soft copper.

With brush type contacts, see that the brush beds squarely and all over its surface. Adjust the pressure if necessary. Emery powder or other abrasive should never be used on a laminated brush as it may get between the copper leaves. A precaution necessary when making cable connections is that the terminal stud is not turned when tightening the nuts; the stud should be held firmly when tightening up so that there is no strain on the cable. The ground connection should be checked to see that all the supporting framework is in good connection with the ground bar, and that this bar is in good contact with the station ground plate.

Reclaiming Heat *from* Internal Combustion Engines

Heaters for Utilizing the Jacket Water and Exhaust Heat in Building Heating and Process Work

By L. M. JORDAN

BECAUSE THE INTERNAL combustion engine is constantly growing in popularity, question is often raised whether a combination plant of steam and Diesel engine types is desirable, from which mechanical energy may be derived from a portion of the fuel and heat energy from the remainder. Undoubtedly where a long winter season necessitates prolonged heating, the steam power plant has advantages even though it be more complicated in structure. Heat ordinarily wasted from Diesel engines can, however, be utilized to a considerable extent. For instance, in a Diesel engine of 500 hp., approximately 25 per cent of the heat is lost through the exhaust, 8 per cent through friction, 33 per cent in the jacket water, while only 34 per cent is developed into useful work. In the steam engine of the same horsepower, 52 per cent is lost in the exhaust steam, 8 per cent in friction, 30 per cent is lost in the boiler and only 10 per cent goes into useful work. Another advantage of the oil engine is that size has little influence on efficiency, so that for small power plants, it has a good chance to make a favorable showing; also variation in load, within the ordinary working range, has less effect on the efficiency than in the case of the steam engine.

Where the heating period is short, or the heat demands of the plant are small compared with the power load, the oil engine has every reason to be considered. Even in a plant such as a laundry, where considerable hot water is required, the waste heat from the internal combustion engine can be used to good advantage. It may be desirable to use the heat from the jacket water and the exhaust separately or it may be better to utilize them on the same process, using the jacket heat for the first step, then an exhaust gas heater in series to raise the temperature still further.

Heat Losses in Combustion Engines

For common practice it will be safe to estimate the jacket water loss as 50 per cent of the total heat loss of the engine, although this will vary to some extent with operating conditions and the size of the plant. Average oil consumption of a Diesel engine may be taken as 0.44 lb. per hp-hr. at rating, a good average grade of oil having about 19,000 B.t.u. per lb. Considering the total heat loss in the Diesel engine as 60 per cent of that in the fuel, the available waste heat will then be $0.44 \times 19{,}000 \times 0.6 = 5016$ B.t.u. per hp-hr. or, for practical purposes, it may be considered as 5000 B.t.u. The portion in the jacket water will then be $5000 \times 0.6 = 3000$ and the balance, or 2000 B.t.u. in the exhaust gases.

For smaller engines, the heat loss will be greater, as high as 5400 B.t.u. per hp-hr. in jacket water and 3600 B.t.u. in exhaust gases. If the jacket water can be used directly most of its heat can be salvaged. Exhaust gases, if used for making low-pressure steam will return only 60 per cent of their heat content. Heating water will give somewhat better economy. With suitable equipment, some 75 per cent of the total waste heat can be reclaimed, practice showing from 3500 to 6000 B.t.u. salvaged per hp-hr.

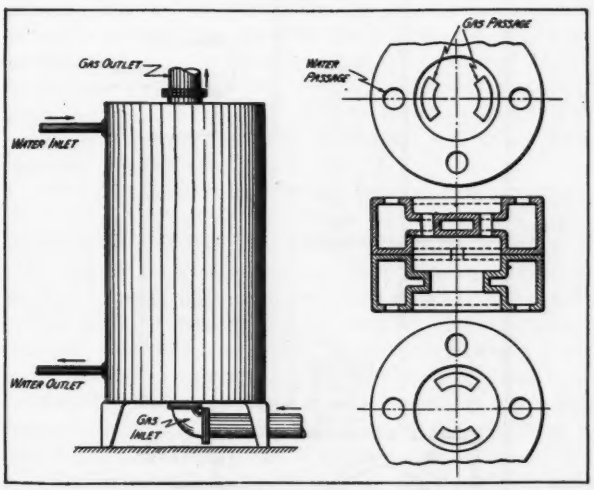


FIG. 1. DETAILS OF HEATER FOR UTILIZING WASTE HEAT

Jacket Water Needed

As to temperatures involved, the final temperature of jacket water should be not over 165 deg. F. to avoid poor ignition and sticking pistons. Under 160 deg. lowers the efficiency of the engine.

For winter, the jacket water range will be say 160 — 50 = 110 deg. and for summer 160 — 70 = 90 deg. Since a gallon of water absorbs about 8 B.t.u. for each degree rise in temperature, it will take up 880 B.t.u. in winter or 720 B.t.u. in summer. Jacket water needed per horsepower-hour will then be $5400 \div 880 = 6.1$ gal. in winter and $5400 \div 720 = 7.5$ gal. in summer. From 5 to 8 gal. are usually used but tests show that more satisfactory results are realized if water is circulated at five or more times the rate usually employed.

This would give approximately 50 gal. per hp-hr. and, as each gallon absorbs 8 B.t.u. for one degree rise in temperature, the cooling water would have a heat capacity of 400 B.t.u. per hp-hr. for one degree rise, giving a total rise of 14 deg. to absorb the 5400 B.t.u. per hp-hr. sent to the jackets. This would permit using an inlet temperature of 160 — 14 = 146 deg. for the jacket water, which is within the heating work range of ordinary hot-water systems. If the loss of temperature in the hot-water system were 30 deg., then 31 gal. of water per hp-hr. would be sufficient.

Using Exhaust Gas Heat

As the temperature of exhaust gases ranges between 600 and 800 deg., the water for a hot-water heating

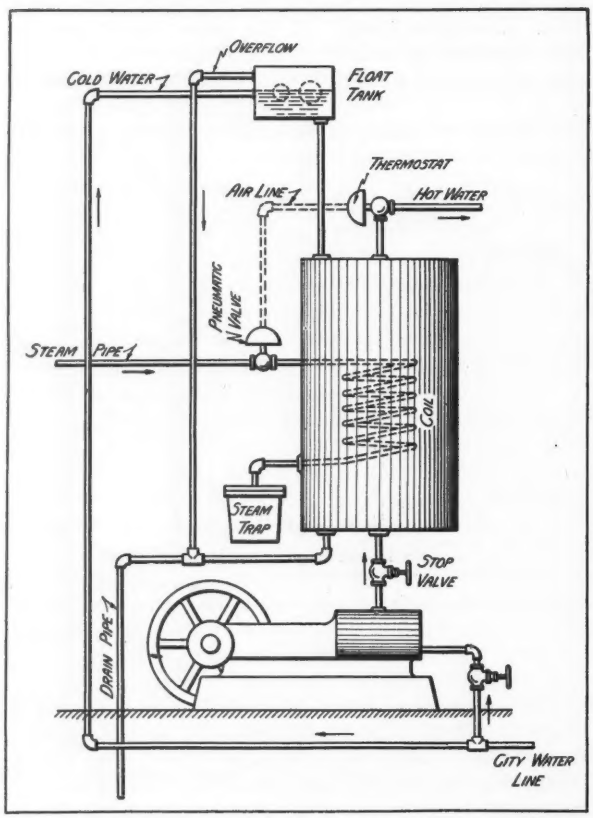


FIG. 2. ARRANGEMENT FOR UTILIZING THE JACKET HEAT

system may be raised considerably above 160 deg. by further heating it with the exhaust gases. As the heat in the exhaust gases is only two-thirds that in the jacket water and it is impossible to get an efficiency of 100 per cent in transferring heat from exhaust gas to the water, the rise in temperature by the use of exhaust gas will usually be not over one-half that due to the heating of water in the jacket.

Temperature Regulation for Process Supply

Where water is utilized for process work and the temperature required is not so high, circulation can be adjusted to give the temperature required but it should be remembered that, in order to get the best action or the internal combustion engine, the final temperature of the jacket water should not be too low, since it requires a certain temperature in the cylinder in order to work at best economy.

Take a case where the water is to be heated from 65 to 165 deg. or through a 100-deg. temperature range. Each gallon of water at 8 B.t.u. per degree rise will take up 800 B.t.u. while being heated and 7 gal. of water will be required to circulate through the jacket to utilize the 5400 B.t.u. per hp-hr. If water of a temperature of less than 160 deg. is necessary, the jacket water may be mixed with water heated by the exhaust to a lower temperature, so that the desired temperature at the outlet point will result. In case temperature in excess of 160 deg. is necessary, the jacket water may be further heated by the exhaust gases, if the normal supply of jacket water is sufficient for the process work. If it is not sufficient, then some external source of heating will be required.

Heat radiated from a hot-water radiator will depend on the temperature of the water inside, being 187 B.t.u. per sq. ft. per hr. for a water temperature of 180 deg., radiation planned for zero outside temperature and 70 deg. room temperature; or 138 deg. for a water temperature of 151 deg. Then 180 deg. is about what can be realized by utilizing both jacket water and exhaust gases for heating. As outdoor temperature rises, less heat will be required in the rooms and the exhaust heater can be cut out of service, gradually, until finally all exhaust gases are bypassed around the heater. If a further reduction of the water temperature is required, the circulating pump speed can be reduced, sending less quantities through the radiators and bypassing part of the jacket water, if necessary, through a cooling tank.

Gas-Fired Boilers

As a gas-fired boiler, an ordinary hot-water heating boiler may be used by removing grates, sealing ashpit and fire doors by gaskets and delivering exhaust gases to the ashpit underneath a baffle plate. A greater capacity may be had by forming a boiler from sections of types of cast-iron heaters as shown in Fig. 1, the sections being so constructed as to split up the gas current by alternation of the flue gas passages. The boiler can be built of any desired height to give the required heating surface by using the sections necessary. Water connections should be such that the flow of water is counter current to that of the gases in order to get best efficiency. For average conditions the gas boiler can contain approximately 2¾ sq.ft. of heating surface per horsepower of the engine, where the heater is operated in series with the jacket. If parallel connection is practiced, this heating surface may be reduced to 2.3 sq.ft. per hr.

Where unit heaters are used with a fan and blower system, the jacket water temperature can usually be reduced from 160 deg. to 120 deg., while heating the air from 60 deg. up to 100 deg. This will require circulation of about 16 gal. of water per hp-hr. in the small size engine or considerably less in the larger Diesels.

System for Jacket Heat Salvage

Figure 2 illustrates a good arrangement for utilizing internal combustion waste heat in large buildings or for industrial purposes. Cold water is taken into the cylinder jacket, then passes to a storage tank which is

equipped with a steam coil to supplement the jacket heat when necessary. Pressure required to elevate water to the highest point and expel it at the required velocity is had through connecting the storage tank with a flow tank elevated at sufficient height as shown. Volume of water passing through the engine jacket of the storage tank is controlled by a throttle valve adjusted to a uniform, consistent temperature of jacket discharge water. This may be supplemented, if desired, by a thermostatic valve in the same line and approximately at the same point. If the engine is carrying uniform load and water is obtained from a city main, the throttle valve will be sufficient, but, in the event of considerable fluctuation of either the load or the incoming water temperature, the thermostat should be employed. Overflow

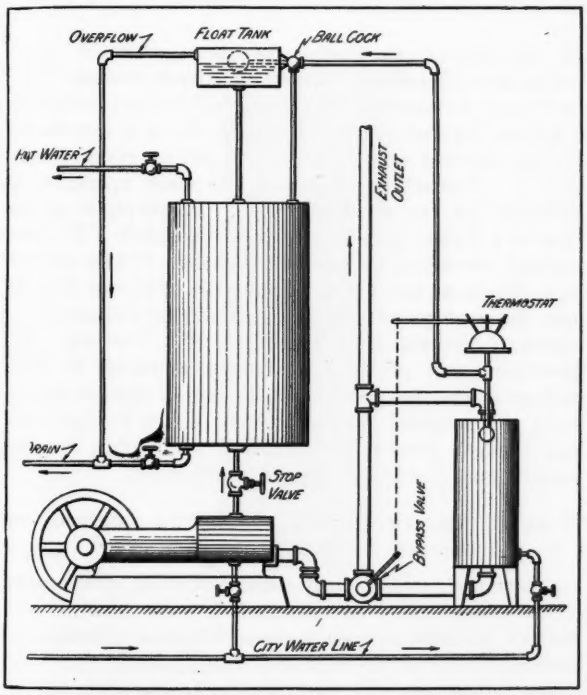


FIG. 3. COMBINATION SYSTEM FOR UTILIZING HEAT FROM BOTH JACKET WATER AND EXHAUST GASES

will occur from the float tank when the jacket water produced exceeds the demand of the building or process work and, if the jacket water is insufficient to supply the demand, cold water will be received from the city mains through the small cock in the flow tank, the steam coils, automatically regulated by hot-water thermostats, supplying the necessary extra heat.

Utilizing Jacket and Exhaust Heat

In Fig. 3 is shown a system for utilizing both jacket water heat and part of the exhaust gas heat. Adjustment of the throttle valve controls the required amount of water passing through the jacket in proportion to the existing differences in pressure and to give a discharge temperature from the jacket of 160 deg. Here, as before, if the load or the inlet temperature of the water varies greatly, a thermostat should be employed in the pipe between the engine and the storage tank to control the flow of jacket water. Any makeup water required comes through the gas boiler heated by exhaust gases, the amount being regulated by the float-controlled valve. The arrangement utilizes as much or as little of the exhaust gas heat as required, the thermostat on the gas-heated boiler being set to keep the water in the boiler at the temperature desired in the main storage tank.

New Steam Plant at Bremo Bluff, Va.

On the James River at Bremo Bluff, Va., the Virginia Public Service Co. has begun construction of a new steam generating plant which will have an initial installed capacity of 30,000 kw., to be subsequently increased as growth and development of the territory warrant. The Bremo Bluff stations, which will cost approximately $3,000,000, will be the base load plant for the entire inter-connected system of the company on its completion early in 1931.

Located in Fluvanna County, about 30 mi. from Charlottesville, general headquarters of the company, the Bremo Bluff station will stand at the geographical center of the system. A double circuit 66,000-v. transmission line will be built from the plant at Charlottesville, to provide the tie with the company's inter-connected system. Construction of this line started at the same time as construction of the station. Distribution lines will radiate from the plant to various points in the adjacent territory to serve residential and other consumers.

The initial installation will comprise two compound turbine-generators of 15,000-kw. capacity each, to be operated at 450 lb. pressure at an initial temperature of 750 deg. F., with provisions for future operation at higher temperatures. One of the outstanding features of the station is that it will be arranged for centralized control, with all the controls brought to a single position, so that one person can operate both the electrical and mechanical parts of the station, including the boiler room. This will permit operation of the plant at a maximum of efficiency and a minimum of labor.

The boilers will be single-pass vertical type with pulverized coal furnaces, having three burners and pulverizers per boiler. Two boilers are to be installed at the outset and space provided for a future third. They will be equipped with air heaters of a new type and with combustion control for each burner, which will be operated from control board sections of a new and advanced design. Coal will be handled by conveying apparatus to a multiple bunker directly over the pulverizers, which are to be of the ball type. Provision also will be made for coal storage up to about 25,000 t.

Water will be brought into the plant from the James River by means of a canal to be built beneath the tracks of the Chesapeake and Ohio Railroad passing by the station. About 28,000 g.p.m. for each turbine will be drawn from the river to be used for condensing purposes and then returned to the river. Although the details of the station building proper have not been completed as yet, it will be of an attractive design, using Virginia red face brick and following the lines of the most modern power plant architecture and construction. When the station is placed in service, plans are to be made for conducting supervised tours of the project so that tourists along the highway and other visitors may be given firsthand information as to the operation of a modern electric plant.

Control Equipment for Synchronous Motors

Part IV. Protective Features. General Recommendations Governing Selection and Control of Auxiliary Equipment.

By C. P. ROBINSON
Ideal Electric & Mfg. Co.

FEATURES OF MOTOR protection are usually the same in both full automatic, full voltage, and full automatic reduced voltage starters, but not all manufacturers provide protection in the same manner. In general, the following items of protection for the motor will be provided with the standard starter.

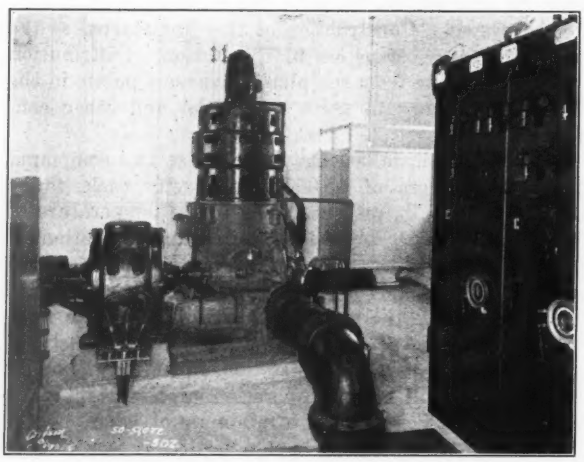


FIG. 1. TWO PANELS, TWO SYNCHRONOUS, ONE MAIN PUMP MOTOR, ONE BOOSTER PUMP MOTOR

(a) Protection from a.c. voltage failure or low a.c. voltage,

(b) Protection from d.c. voltage failure or interruption,

(c) Protection from overload while running,

(d) Protection from overload during starting period,

(e) Protection against single-phase operation and

(f) The operator is protected against high voltage.

Since the control circuit is usually single phase, a.c., voltage failure causes the main line contactor and field contactor to drop out, thus removing the motor from the line. Low a.c. voltage protection may be provided by the no voltage release coil when designed for this purpose or may be provided by the overloads.

Low line voltage causes the motor line current to increase, which in turn will trip the overloads if a safe current value is exceeded. Overload protection under normal running conditions needs no further explanation. This protection during starting may be secured by use of the thermal or temperature type overload relays which have an inherent inverse time limit characteristic; or it may be secured when using oil dashpot relays by a bypass current shunt adjustment which is introduced during starting and then cut out during running conditions. Protection against single-phase operation is provided by the overload relays. Single-phase operation of a 3-phase motor causes approximately 1.73 times normal current in the operating phase. If this current is sufficient to damage the motor, the overloads trip; if not, the open phase will be discovered by failure of the motor to re-start after being stopped. Protection for the operator is provided by remote mounting of high-voltage equipment and proper protection against danger from the potential transformer energizing the low-voltage control circuit. In addition all switch frames, meters, etc., should be effectively grounded.

General Recommendations Governing Selection of Control and Auxiliary Equipment

Now that each typical classification of synchronous motor control has been discussed in some detail, it will be well to include some recommendations referring, in general, to all of the representative types.

Oil Immersed Switches Versus Air Break

Previous mention has been made of the particular types of starters which may employ either the air break or the oil immersed switches. Standards vary considerably over the country but the following recommendations will cover, in general, the comparative status of the two types of switches.

A—Air break contactors may be used up to 125 hp. at 220 v., 250 hp. at 440 v. or 300 hp. at 550 v. Above these ratings air break switches are not recommended.

B—Air break contactors should not be used above 550 v.

C—Oil switches are recommended for larger hp. ratings at the low voltages.

D—Oil switches should be used for all voltages above 550 v. For applications above 2500 v., the oil switch should be mounted remote from the panel.

Oil immersed switches are recommended for the higher ratings at low voltage because of their greater interrupting capacity and freedom from danger of arcing due to the breaking of heavy currents. In the case of high-voltage installation, the oil switch protects the

operator from arcing due to the high potential. Also in both cases, the action of the oil is to quench the arc quickly, resulting in longer life for contactors. It is true that installations have been made using air break switches for low-voltage applications, greatly exceeding the limits recommended; however, it is not conceded to be the best of practice from the standpoint of operator's safety and maintenance of equipment.

Selection of Control

The applications for the various types of synchronous motor control panels have been mentioned briefly in connection with the individual discussions. A summary, with a more detailed explanation from the standpoint of control selection, will distinguish the characteristics more clearly.

Briefly, synchronous motors may be divided into two

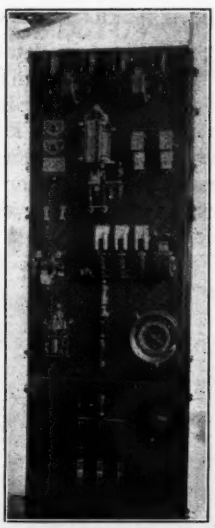


FIG. 2. MAIN PUMP MOTOR CONTROL PANEL ALONE

classifications: (1) slow-speed motors and (2) medium and high-speed motors.

(1) Slow-speed motors range from the lowest speeds up to 450 r.p.m. Motors of this type, suitable for driving compressors, reciprocating pumps, line shafts, etc., will have approximately the following characteristics:

Starting torque ..... 40 to 50 per cent
Pull-in torque ..... 40 to 50 per cent
Inrush current .....250 to 300 per cent

In practically all cases, the motors are started without load other than friction of machinery. Means are provided to bypass ammonia or carbon dioxide compressors or to unload air compressors, until the motor has accelerated to full speed and is in step. Power companies will usually permit starting motors directly across the line, where the inrush current drawn from the line does not exceed 300 per cent.

Starters available for motors in this classification are:

(1) The manually operated full-voltage starter.
(2) The semi-automatic full-voltage starter.
(3) The full-automatic full-voltage starter.

For a particular installation, the selection of a starter should be made only after a careful analysis of the relative advantages and disadvantages of each type.

A manual operated starter has the advantage of lowest initial cost but a disadvantage in requiring careful operation. For the smaller motor applications where infrequent starting is the rule and where careless handling is not apt to be serious, the manual starter may be successfully and economically applied.

Semi-automatic starters have advantages in requiring less skilled attention than the manual starter. They have the advantage of partial automatic control and impose less hardship on the motor than manual starters. They cost more than manual starters but less than the full-automatic starters. Their main disadvantages as compared to full-automatic starters are that they do not afford as complete protection for the operator. Where the installation is not of sufficient size to warrant the extra expense of a full-automatic starter, the semi-automatic starter will be found very serviceable and satisfactory.

The advantages of a full-voltage full-automatic starter require small mention. The operator is afforded full protection. Pushing a button is the only operation required. The motor starts and synchronizes each time in the same manner. The control is adjusted so that the sequence of operation provides least strain on the motor. Probably the main disadvantages to the full-automatic starter are the higher initial cost and the extra maintenance involved. The extra cost is usually warranted on installations of 100 hp. or higher; and in many cases for ratings below 100 hp. depending upon the location of the equipment and ability of operators. The cost of the full-voltage starter is not so much in excess of the simpler types as to be prohibitive. The extra maintenance involved can usually be taken care of, by a weekly inspection of control apparatus, to make sure that all contact points are clean and bright, and are making good contact as the relays function.

(2) Medium and high-speed synchronous motors range from 514 r.p.m. up in speed. Motors of this type suitable for driving fans, blowers, conveyors and line shafts, compressors, centrifugal and rotary pumps, and for many other general purpose applications will have approximately the following characteristics when started on full voltage.

Starting torque .....125 to 175 per cent
Pull-in torque ..... 90 to 110 per cent
Inrush current .....500 to 600 per cent

In practically all cases, the motors are started on reduced voltage as power companies will not permit such high starting currents. Also, these motors are often started against a load. As the starting torque goes down as the square of the auto-transformer tap used, care must be exercised when applying reduced voltage to make certain that the torque requirements of the starting load will be met.

Starters available for motors in this classification are:

(1) The manually operated, reduced voltage starter.
(2) The semi-automatic, reduced voltage starter.
(3) The full-automatic, reduced voltage starter.

Selection of a starter in this case follows the same principles as outlined for full-voltage starters. The main point is that a larger cost differential exists between each of the successive types, due to the fact that more elaborate automatic equipment is required. The same analysis, however, should be made based on the

relative advantages and disadvantages of each type of starter before making a decision

Special Applications and Remote Control

There are many kinds of special application too numerous to mention which do not adhere to standard practice. One of these typical of full voltage starting is a rubber roll mill application. Here the torque requirements are severe. The friction load alone is very

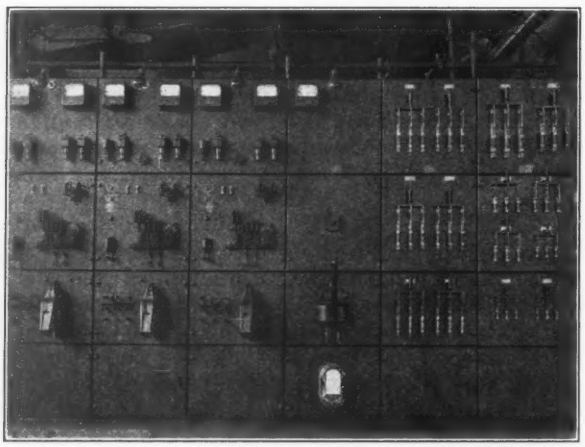


FIG. 3. A SIX-PANEL SWITCHBOARD

heavy. Rubber mill specifications usually call for 125 per cent starting torque, 110 per cent pull-in torque and 450 to 500 per cent starting inrush on full voltage. Heavy service lines and large transformer capacity are provided to take care of these severe starting conditions. Power companies make concessions to mills of this type where the nature of the loads are unusually severe. The motor may be either slow speed direct connected to the rolls or it may be medium speed driving through a gear speed reduction. The same characteristics are required in either case. A full-automatic full-voltage starter is employed, usually with provisions for dynamic braking of the motor (for operator's safety) controlled by auxiliary automatic relays.

Figure 1 shows a two-panel switchboard consisting of two full-automatic reduced voltage starters for controlling a deep well pump motor and a booster pump motor. The operation of the two motors is tied together through pressure gages on the water system. A special relay protects the deep well pump and motor when stopping. The impeller of the pump is many feet below the ground surface. When the motor stops pumping, there is practically a full column of water still in the deep well casing. This water flowing back down into the well, causes the motor through the impeller on the pump to be driven backwards at a fairly high rate of speed. The special relay prevents the establishment of an electrical circuit to the motor until the motor has again come to rest, thus protecting the motor, shaft, and pump against twisting strains. Figure 2 illustrates the main pump motor control panel alone.

The booster pump, through its pressure gage, does not start up until the main pump motor has pumped up water to a predetermined pressure. In addition, a time relay (providing about one minute time delay) is used to prevent the booster pump motor control from shutting down immediately after starting, due to surges of water pressure caused by static friction and load on the water line.

Pressure gages are often used for automatic control of synchronous motor-driven air compressors and other similar applications.

These examples simply indicate what may be accomplished in the way of special control. There are many other similar cases where the introduction of special relays eliminates the human element in synchronous motor operation.

Remote control for synchronous motors is sometimes desirable. Large steel mills, for example, often centralize their main motor starting panels in one control room. A system of signal lights function or a bell rings, and one operator performs the necessary starting and stopping functions for many motors.

Selection of Auxiliary Equipment

The equipment mentioned in detail for the various types of starters represented the minimum. Quite often additional meters are desired in order to keep an accurate check upon power costs. A kilowatt-hour meter records the kilowatts or useful power consumption. A reactive meter records the wattless or wasted kv-a. consumption. A power factor meter shows at a glance

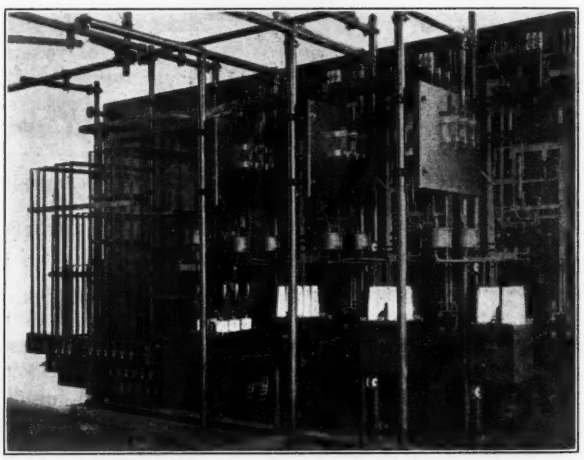


FIG. 4. REAR VIEW OF SWITCHBOARD SHOWN IN FIG. 3

whether or not a penalty for poor power factor is to be expected.

As synchronous motors correct poor power factor caused by induction motor or other inductive load, a power factor meter giving a reading on the whole system is valuable. With only a power factor meter in addition to a standard panel, an operator can keep his power bills at the minimum. Wherever power companies penalize their customers for low power factor, as is quite generally the case, the plant manager should strive to maintain his plant power factor as near 100 per cent or unity, as possible.

As an example of auxiliary equipment incorporated into a complete switchboard, Fig. 3 illustrates a six-panel switchboard, consisting of three push-button operated full-automatic full-voltage starters on the left, an incoming panel next and two distribution panels for smaller auxiliaries, on the right. The incoming panel

provides a main circuit breaker, a kilowatt-hour meter, and a voltmeter with an 8-point receptacle for reading voltage on eight different points of the system as desired.

Figure 4 shows a rear view of the same 6-panel switchboard. Note the elaborate wiring and bus bar work required. Most operators, when pushing the button, do not appreciate the large amount of constructive and creative effort required back of the board, in order that pushing the button may accomplish its intended purpose.

These illustrations do not, by any means, cover the entire range of possibilities as far as complete switchboards are concerned, but will serve as an indication of accomplishments along this line. The subject of synchronous motor control is an interesting one. Not all installations comply with the general standards suggested. Many applications require special features in order to meet with local rulings. New problems are constantly being encountered. Volumes could be written covering the solutions found for special problems.

Just as the past few years have seen progress in the development of control apparatus for synchronous motors, so will the next few years bring new developments to light under the continual research activity which is being carried on throughout the world. It is impossible to predict accurately what these developments may be, but it is safe to assume that progress will be made towards improving and perfecting, even supplanting present day equipment with apparatus more highly efficient and even more satisfactory than that now in daily use.

Electricity---What It Is and How It Acts*

PART XL. FURTHER CONSIDERATIONS OF THE STRUCTURE OF MATTER. DISRUPTION OF ATOMIC NUCLEI BY HIGH-SPEED ALPHA PARTICLES. BY A. W. KRAMER

IN THE SUCCESSIVE transformations of radioactive elements from uranium to lead, it was shown that in all cases these transformations are accompanied by the emission of either alpha particles or beta particles. This is an extremely significant fact for it lends proof to the hypothesis that all atoms are multiples of some simple unit. Since both alpha particles (helium nuclei) and beta particles (electrons) are expelled during radioactive transformations, we can assume that the nuclei of radioactive atoms are made up in part at least of both helium nuclei and electrons. It must be understood that in the disintegration processes, it is the nucleus of the atom which is involved, for it is only by taking away or adding to the nucleus that the character of the atom can be changed.

Now, we know from our study of the arrangement of electrons and protons in atoms that the simplest of all atoms is that of hydrogen, consisting of a single proton and one external electron. Knowing this, it is rather curious that it is the helium nucleus, rather than the hydrogen nucleus, that should be ejected in radioactive transformations, for if the hydrogen atom is the simplest of all atoms, it would seem logical to assume that this is the unit of which all other atoms are composed. But radioactive distintegration never has yielded any trace of hydrogen!

This state of affairs led Sir Ernest Rutherford and Dr. Chadwick to devise a series of remarkable experiments. An alpha particle say from Radium C, they knew, possessed tremendous energy, in fact, it was the swiftest and most powerful projectile available on earth. These particles traveling at speeds of 10,000 times the speed of a rifle bullet have some 400,000,000 times its energy, mass for mass. With this inconceivably swift and powerful projectile, they proposed to explore the very heart of the atom. They reasoned that if a projectile could be fired at an atom swiftly enough, it would penetrate into the nucleus and under certain conditions, disrupt it.

It must be kept in mind, that as we approach an atom from the outside, the inverse square law of force holds true until the innermost ring of electrons is reached. Beyond that point the law must change, for otherwise the atom could not hold together. The nucleus carries an excess positive charge; therefore, since like

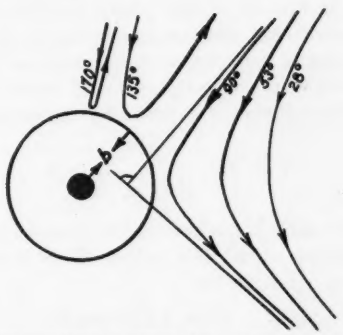


FIG. 1. DEFLECTION PATHS OF ALPHA PARTICLES BY HEAVY ATOMIC NUCLEUS

charges repel, the protons would repel each and unless some other factor entered in, there would be nothing to keep the nucleus intact. The nucleus is surrounded by a region of impenetrability.

This action can be illustrated by a simple experiment. Suppose a powerful solenoid or electromagnet be placed at the center of a table and that directly above it, there is suspended a smaller magnet, so that when the latter is drawn to one side it will tend to swing, as a pendulum, over the stationary magnet. These magnets represent two similar poles. It will be found, however, that with the fields on, the pendulum will not hit (or pass closely over it) the large pole but will swing round in a curve *except when the speed of the pendulum is very high.*

In the same manner, an alpha particle shot against say a sheet of gold foil, would not penetrate into the atom of gold towards which it was directed but would be sent back or deflected in a curve. If the center of gravity of the two atoms (the alpha particle and the gold atom) were in a line with the direction of approach, the alpha particle would bounce straight back upon its

*All rights reserved.

path but if the centers of gravity are disposed otherwise, the alpha particle will be deflected in a curve, as shown in Fig. 1.

Effect of Impact of Alpha Particles Upon Light Atoms

An atom of gold,[1] however, is exceedingly massive compared to an alpha particle and we are scarcely justified in assuming either that an alpha particle could penetrate far into the nucleus of an atom of gold or that it could disturb it greatly. Suppose, however, we consider the impact of the alpha particle on a very light

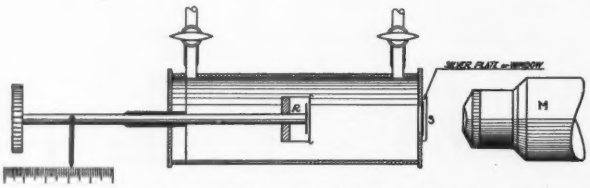


FIG. 2. FORM OF ATOMIC DISRUPTION APPARATUS USED BY RUTHERFORD

T is a brass tube which may be exhausted or filled with the gas to be investigated. R is a source of alpha particles fixed to the end of a sliding rod so that its distance from the zinc sulphide screen may be varied. A microscope M is provided to observe the scintillations on the screen S.

atom, hydrogen, for example. It is easy to show that the velocity, u, of the struck nucleus will depend upon the masses M and m of the alpha particle and struck nucleus respectively and upon the angle ϕ which the path of the nucleus makes with the original path of the alpha particle whose velocity is v. If there is no loss of energy in the collision it is given by the expression

$$u = 2\,v\,\frac{M}{M+m}\cos\phi$$

When the struck nucleus is the proton (the nucleus of the hydrogen atom) the values M = 4 and m = 1 simplify this equation to

$$u = 1.6\,v\cos\phi$$

Thus, after the collision, the nucleus of a hydrogen atom struck by a swiftly moving alpha particle, would travel outward (assuming direct impact, $\phi = 0$) with a velocity 1.6 times that of the alpha particle itself.

Now, in a given gas, a proton has about the same range as an alpha particle travelling with the same initial velocity, the effect of the reduced mass and of the reduced charge nearly annulling one another in this respect. The range of an alpha particle is proportional to the cube of its velocity; therefore, for direct impact, the range of a struck proton is about $(1.6)^3 = 4.1$ times the range of the alpha particle itself in the same gas.

Thus, with an alpha particle from radium C whose range in hydrogen is 31 cm., the range of the proton which it strikes centrally should be 127 cm. in hydrogen. This then makes it possible to distinguish easily between struck protons and the alpha particles themselves, since the greater range of the former allows them to be detected at much greater distances from the source than the latter. Of course, it is only the full collisions that lead to so long a range. Collision at an angle, as indicated by the foregoing equation, produces protons with smaller velocities and therefore shorter ranges.

[1]Atomic weight 197.2; atomic number 79.

Method of Effecting Atomic Disruption

The form of apparatus used by Rutherford and Chadwick in these investigations is shown in Fig. 2. It consists of a brass tube T, 3 cm. in diameter, provided with a small hole at one end covered by a window of thin silver. The tube can be exhausted or filled with any gas. The stopping power of the silver window, for alpha particles, is equivalent to about 5 cm. of air. The particles which pass through this window produce scintillations on a zinc sulphide screen S placed just beyond which may be observed in a microscope M. A radioactive source, R, is fitted on a sliding rod so that its position in the tube can be varied.

If this tube is filled with hydrogen, the chances that an alpha particle will actually collide with a hydrogen nucleus and disrupt it are extraordinarily remote, perhaps one in one million but if it does, the hydrogen nucleus (or proton) hit, should by the above equation be propelled in the direction of the alpha particle with 1.6 times the speed of the latter. Striking the screen, if not too far away, the proton will cause a scintillation. Now, the numbers of such scintillations actually observed proved to be far in excess of the numbers to be expected if both the alpha particle and the proton were merely point charges. Far more protons were thrown directly forward than the formula indicates. This consideration first led Rutherford to assume the alpha particle to have a plate-like form, the plane of the plate being normal to the path of the nucleus. Since the collision in such cases of very close approach is practically "head-on" to the line joining the centers of the two nuclei, this would give a preferential projection of the struck nucleus in the line of motion of the alpha particle.

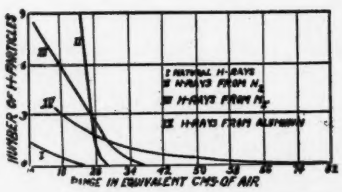


FIG. 3. CURVES SHOWING RANGE OF PARTICLES FROM VARIOUS ELEMENTS WHEN SUBJECTED TO BOMBARDMENT BY HELIUM NUCLEI

When the tube was filled with air, or pure nitrogen, scintillations were observed when the distance between R and S far exceeded the range of the alpha particle (7 cm. in air). In the case of air, particles were observed at 28 cm., four times that of the alpha particle, and just what we should expect the range of a struck proton to be. In the case of oxygen, the number of scintillations were scarce, but when nitrogen was introduced or even pure air, the number rose fourfold.

A large number of control experiments were made, as a result of which it was definitely established that the passage of the alpha particles through nitrogen produces particles whose long range gives strong reason to believe that they are protons. Rutherford proved that this really was their nature, by deflecting them in a magnetic field.

The only possible source of these long range protons is the nucleus of the nitrogen atom. When an alpha particle hits a nitrogen nucleus fair and square, it is

able to detach from it one of the protons which go to make up its structure, and hurl it in the forward direction. The extreme forward range was later found to be not 28 cm. but 40 cm. which makes the proof of the nuclear origin of the proton even more definite, the additional energy being derived from the nucleus itself.

In one sense, this experiment is among the most romantic in science, as it brings to a realization the long cherished dream of the ancient alchemists, transmutation of the elements; for what we are observing when we look into the eyepiece of the microscope is the production of hydrogen from nitrogen. The nucleus of the nitrogen atom (atomic weight 14.01, atomic number 7) is shattered into one or more atoms of hydrogen and what is left is not nitrogen any more. If only one proton (hydrogen nucleus) is knocked out, what is left of the nitrogen atom is carbon (atomic weight 12, atomic number 6). True, in all of these experiments the amount of matter transmuted was infinitesimally minute but it was transmutation, nevertheless.

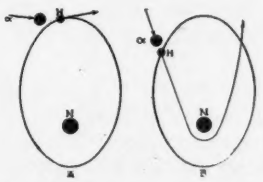


FIG. 4. DIAGRAM ATTEMPTING TO EXPLAIN THE REVERSE PROJECTION OF HYDROGEN NUCLEI FROM ALUMINUM ATOMS DUE TO THE DIFFERENCE IN THE DIRECTION OF THE ALPHA PARTICLE WITH RESPECT TO THE ALUMINUM ATOM

A number of the lighter elements were investigated to determine whether protons were expelled from their nuclei. Where a solid was to be investigated instead of a gas, a thin strip of metal foil was placed directly over the radium C or alpha particle source. With heavy atoms, gold, lead, etc., the expulsion of protons was not to be expected for, as has been pointed out, the high nuclear charge on such atoms exerts so high a repulsive force on the alpha particle, that the latter cannot effect a close approach to the nucleus.

With the lighter elements, long range particles were detected in the case of boron, fluorine, neon, sodium, magnesium, aluminum, silicon, phosphorus, sulphur, chlorine, argon and potassium as well as the original nitrogen.

In the case of aluminum, the protons expelled in the forward direction were found to have a range of 90 cm. in air as contrasted with a range of 7 cm. for the alpha particles themselves, or 29 cm. for a free proton thrown straight forward by the impact of an alpha particle. The energy of the proton from aluminum, therefore, is considerably in excess of the alpha particle which produces it, involving an actual gain of energy as the result of the collision. There has been a considerable release of nuclear energy.

Aluminum, in common with several other elements, also exhibited another peculiarity. In most cases the hydrogen nuclei producing scintillation travelled on in the direction of the alpha particle but in the case of aluminum was almost explosive and nearly half of the nuclei seemed to be reflected back. That might be explained by Fig. 4. If it were one of the hydrogen satellites of an aluminum nucleus that was struck by the alpha particle, that satellite would, as in the case of Fig. 4A, travel straight on; but in the case shown in Fig. 4B it would describe a partial orbit, and almost appear to be reflected.

Conclusions Drawn from Experiments Regarding Atomic Structure

While many elements produced protons in this manner when bombarded, there were notable exceptions. These were carbon, atomic weight $12 = 3 \times 4$; and pure oxygen, atomic weight $16 = 4 \times 4$. Boron, on the other hand, with atomic weight $11 = 2 \times 4 + 3$; nitrogen, atomic weight $14 = 2 \times 4 + 2$ and fluorine, atomic weight $19 = 4 \times 4 + 3$, did emit hydrogen nuclei. It is well to examine the atomic weights of these elements carefully for they provide a clue to the basic structure of all elements. It will be noted from the above examples that elements whose atomic weight is evenly divisible by 4, do not provide protons, while those whose atomic weight is *not* equally divisible by 4 will give protons. That is to say, elements of atomic weights 4 n + a give hydrogen nuclei, while those of atomic weight 4 n do not.

This fact and other considerations suggested that the atoms of all elements consist of helium nuclei of mass 4 and sometimes also of hydrogen nuclei. In other words, hydrogen and helium are the fundamental bricks out of which all atoms are built. Nitrogen with atomic weight 14, for example, is composed of 3 He + 2H, and the carbon atom (C = 12) of 3 He, that is, three charged helium nuclei with 6 surrounding electrons. This may be expressed 3 He $^{++}$ + 6 e $^{-}$.

HYDROGEN RAYS FROM VARIOUS ELEMENTS

Disengaged by means of alpha rays from Ra-C (7 cm. range)

Element	Atomic Number	Atomic Weight	Number of Particles per min. per mg.	Maximum range in cm. in air of atmospheric pressure
Lithium	3	6, 7	....	..
*Beryllium	4	10	....	..
Boron	5	10, 11	0.15	45
Carbon	6	12	....	..
Nitrogen	7	4	0.7	40
Oxygen	8	16	....	..
Fluorine	9	19	0.4	above 40
Sodium	11	23	0.2	42
*Magnesium	12	24, 25, 26	....	..
Aluminum	13	27	1.1	90
*Silicon	14	28, 29	....	..
Phosphorus	15	31	0.7	65
*Sulphur	16	32	....	..
*Chlorine	17	35, 37	....	..
*Potassium	19	39, 41	....	..

*In these instances, atomic disruption was accomplished after the data for this table was obtained.

Why all elements should be formed in this manner of units consisting of multiples of the smallest unit, is not quite clear, except that the combination of four hydrogen nuclei to form a helium nucleus presents a peculiarly stable arrangement. That this is so is borne out by the fact that the atomic weight of helium is 4, instead of 4.032 as we might expect from the atomic weight of hydrogen. The atomic weight of hydrogen is 1.008. Therefore, when four atoms of hydrogen combine to form an atom of helium, we should expect the atomic weight of the combination to be 4×1.008 or 4.032. But such is not the case; the atomic weight of the four hydrogen atoms when combined to form an atom of helium is 4. What becomes of the 0.032?

The explanation of this loss in weight is to be found

in the electromagnetic nature of mass. Mass or matter and energy are convertible; matter is potential energy and energy is potential matter. When four atoms of hydrogen are brought together to form an atom of helium, the excess of matter (i.e. the 0.032) is radiated as energy, in the form of electromagnetic waves. Conversely, to separate the four atoms of hydrogen again, would require a similar amount of energy, and when this amount of energy necessary is computed, we need not wonder at the stability of the helium atom. It can be shown that the transformation of one gram of hydrogen to helium would liberate energy equivalent to 166,000,000,000 calories!

The amount of energy release which would result from the building up of four grams, that is, one-seventh of an ounce, of helium from hydrogen would be equivalent to about one million horsepower for an hour. This enormous energy release theoretically possible, furnishes the starting point for daring speculations as to the possibilities of utilizing interatomic energy.

This release of energy, it will be noted, is obtained not by the breaking down of atoms but by the building up of atoms, and this is something which we do not know how to accomplish. Whether we will ever be able to do this is problematical—perhaps it is well that we cannot, for it is probable that if such a terrific amount of energy were released, at any one point in the world, the effect would be communicated to neighboring atomic systems and if these in turn were thus induced to part with their energy, the process would be progressive and cumulative and the entire planet might be destroyed in less time than it takes to tell about it.

The 53rd N.E.L.A. Convention at San Francisco

PREPARATIONS for the 53rd Convention of the National Electric Light Association are going forward rapidly. Four general sessions will be held during the convention and one session each of the four sections. Where possible, sessions will be held in the Exposition Auditorium, Civic Center, in the heart of San Francisco.

General sessions will be held on the mornings of June 17, 18, 19 and 20; accounting and engineering sessions during the afternoon of June 17; the commercial session on the afternoon of June 18 and the public relation session on the afternoon of June 19. The public policy session will be held on the night of Thursday, June 19. Features of this program will include an address by a prominent speaker; the world-wide communication hookup; award of the Charles A. Coffin Medal and the report of the public policy committee.

Although there will be no manufacturers' exhibits at the convention, a number of instructive exhibits prepared by several of the national sections, bureaus and committees of the Association, as well as by N.E.L.A. headquarters, will be on display.

An interesting program has been arranged for the meeting of the engineering section on Tuesday afternoon, June 17, according to Alex D. Bailey, chairman of the section. Two 45-min. talks by outstanding central station engineers will constitute the principal items on the program at the San Francisco Convention for the meeting on Tuesday afternoon, June 17, devoted to the Engineering National Section. In addition, the Section Chairman will give a brief talk which will be in the nature of a report and an outline of the section's activities for the ensuing year.

A discussion of the trend of costs in production, transmissions, substations and distribution will be the topic of one of the principal speakers. An engineering analysis will be presented of the underlying causes which have produced these trends and which may be expected to govern or influence the future costs of these several divisions of plant and equipment. This subject is one of vital concern to all departments of the light and power business and an engineering analysis of what has taken and will take place in this field should prove extremely interesting and instructive to everyone attending the convention.

It is planned that the second paper shall discuss an engineering problem of particular concern to the Pacific Coast, but one which will command widespread interest. The Pacific Coast, with its special varieties of problems in power supply, in transmission and in the character of loads served, has made many important contributions to engineering knowledge in the light and power industry.

Public relations session will hear the report of its chairman, Harry Reid, and as a second feature, the best three contestants among the winners of the National Employes Speaking Contest will hold the final competition for the selection of the national winner. The third feature will be the awarding of the Forbes Public Service Cup presented each year to that company judged to have performed the best work along the lines of public relations. One of the features of the convention will be the demonstration on Public Policy Night of world-wide communications that will carry the news to Europe, Asia, South America and to ships in both Pacific and Atlantic Oceans. Land line telegraph, submarine cable and radio will play their parts in demonstrating the methods of communication over great distances. From a station in the Civic Auditorium messages will be dispatched to London, Paris and Berlin; Manila and Shanghai, Buenos Aires and other points in South America, and answers will be received.

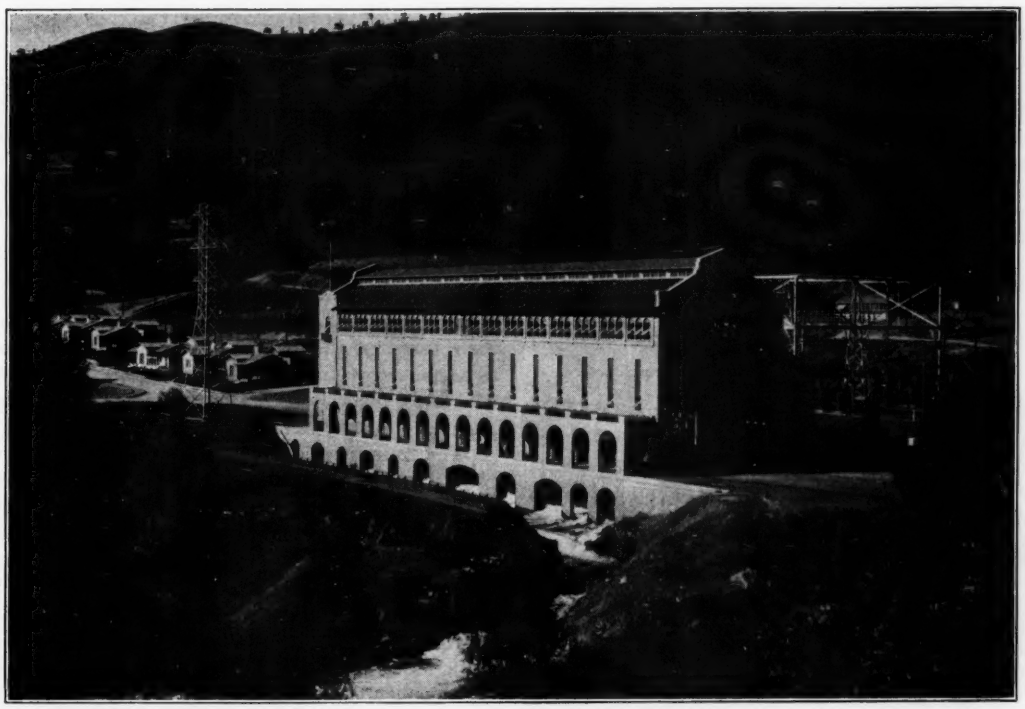
For hotel reservations members should communicate with W. G. Vincent, chairman, Convention Hotel Committee, care of Pacific Gas & Electric Co., 245 Market St., San Francisco. Various special trains will carry members from various parts of the country to the convention and complete details regarding these can be obtained from Robert B. Grove, General Traffic Manager, National Electric Light Association, care of United Light & Power Co., Room 616, 5 Irving Place, New York, N. Y. Full data about the meeting can be obtained from the secretary of the Association, 420 Lexington Ave., New York.

SULZER GEBRUDER of Winterthur, Switzerland, has completed the construction and installation of a 33,000-hp. pumping engine at one of the water storage reservoirs at Herdecke, Germany, for the Rhenish-Westphalian Electricity Co. The pump is one of the largest so far constructed, the biggest one previously built by the Sulzer Co. being of 27,000 hp. for a pumping installation in connection with a hydroelectric plant at Niederwartha near Dresden, Saxony.

Operation of Moccasin and Early Intake Plants

DETAILS OF METHODS OF OPERATING TWO OF THE PLANTS IN SAN FRANCISCO'S GREAT HETCH HETCHY WATER SUPPLY PROJECT. BY C. W. GEIGER

EARLY INTAKE hydroelectric plant is located on the Tuolumne River, a short distance below the dam which diverts the water released from the O'Shaughnessy Dam into the aqueduct leading to Priest Reservoir and the Moccasin power plant. The plant utilizes the waters of Cherry River, supplemented by storage at Lake Eleanor. Early Intake is a small plant of 3000 kv-a. rated capacity, constructed in 1917 to furnish power for construction purposes along the Hetch Hetchy project. During the war, under orders from the Power Administrator, arrangements were made to dispose of the surplus power to the Pacific Gas & Electric Co. Since the completion of the Mountain Division, the plant furnishes electric energy used in the upper division of the project including O'Shaughnessy Dam, Mather Camp and Groveland, the surplus being disposed of to the Pacific Gas & Electric Co. at a point near Moccasin Power House.



GENERAL VIEW OF THE MOCCASIN POWER PLANT OF THE HETCH HETCHY PROJECT

During the portion of the year when there is ample stream flow to operate both plants without drawing from storage, the Early Intake power house is operated at full capacity, 3300 kw. During the late summer and autumn months, when the stream flow is low and stored water is being used, most of the water diverted from the Cherry River is carried past the Early Intake plant to a point just above Tuolumne River diversion dam, thus making the water stored in Lake Eleanor available for the operation of the Moccasin power house, and thereby decreasing the draft from storage in Hetch Hetchy Reservoir. The minimum output of the Intake plant during these months is in the neighborhood of 400 kw.

The output is not uniform, however, because the Intake plant is used to regulate the height of the water at the diversion dam. On account of the distance, approximately 12 mi., between O'Shaughnessy Dam and the point of diversion, from 6 to 8 hr. elapse between the release of water at O'Shaughnessy Dam and its arrival at Early Intake diversion dam. This makes it difficult to maintain the height of water in the small reservoir above the diversion dam at the desired elevation without spilling or wasting water. Also, the amount of water released through the valves at the O'Shaughnessy Dam has a tendency to vary according to the height of the water in the Reservoir.

By varying the load carried by the Early Intake plant, the amount of water diverted from Lake Eleanor storage via Cherry River to Moccasin Power House can be controlled between 0 and 125 c.f.s. A distant-indicating water level gage operated between the diversion dam and Early Intake power house enables the operators to regulate the load so as to hold a given

elevation of water in the reservoir at the diversion dam.

In connection with the operation of the Moccasin power plant, it may be of interest to note that one of the two transmission lines, connecting the power house with the Pacific Gas & Electric Co.'s Newark substation has never, since the commencement of operation in August, 1925, had a power interruption occasioned by failure of any portion of the line or its equipment.

STATISTICAL DATA AS TO POWER OUTPUT AND DISPOSITION—JULY 1, 1927 TO JUNE 30, 1928

Moccasin generated	526,468,000 kw-hr.
Early Intake generated	18,884,300 kw-hr.
Total	545,352,300 kw-hr.
Distribution of above power:	
Consigned to Pacific Gas & Electric—Newark	475,826,400 kw-hr.
Used in city work	12,755,850 kw-hr.
Used at power houses	1,002,160 kw-hr.
Delivered to P. G. & E.—Tuolumne Ct., net	13,032,000 kw-hr.
Losses and unaccounted for	43,735,890 kw-hr.
Total	545,352,300 kw-hr.

Hetch Hetchy power has earned $9,717,229.35 for the city of San Francisco in less than four and a half years. Last year, 1929, the amount paid over to the city was $1,995,136.49. The highest return to the city was in 1927, when it received $2,314,745.66.

Americans Will Preside at Important Sessions of World Power Meeting

OFFICIAL DELEGATES to represent the United States Government at the World Power Conference of 49 nations to be held in Berlin, Germany, June 16 to 25 next, were designated at a meeting of the executive board of the American Committee for the Conference held May 9 in the rooms of the American Society of Mechanical Engineers, 29 West Thirty-ninth St., New York. O. C. Merrill of Washington, chairman of the American Committee and formerly executive secretary of the Federal Power Commission, presided at the meeting.

Those designated as the United States delegates, whose names will be registered with the State Department, are Chairman Merrill; Professor Robert Sibley of the University of California; Henry J. Pierce of the Electric Bond and Share Co., New York, vice-chairman of the American Committee; H. M. Addinsell of Harris, Forbes and Co., New York, treasurer of the American Committee; David B. Rushmore, consulting engineer of New York; Ely C. Hutchinson of New York, editor of Power; George A. Orrok, consulting engineer, No. 52 Vanderbilt Ave., New York; Dr. H. C. Dickinson, chief of the heat and power division of the United States Bureau of Standards; Dr. H. Foster Bain, secretary of the American Institute of Mining and Metallurgical Engineers and Scott Turner, director of the United States Bureau of Mines. The delegates will receive their credentials from the State Department.

American chairmen to preside at important sessions of the power meeting in Berlin were announced following the meeting yesterday. These men, whose names have been filed with the German Committee in charge of Conference arrangements, are Professor Robert Sibley of the University of California, selected to be chairman of Section Two, devoted to the subject Electricity in the Crafts and Industry; Irving E. Moultrop, chief engineer of the Edison Electric Illuminating Co., Boston, chairman of Section Seven, devoted to the topic Construction and Operation of Large Power Plants; Col. J. P. Jackson of the New York Edison Co., to be vice-chairman of Section Three, given over to the subject Three Dimensional Load Models and Current Tariffs; W. S. Monroe, president of Sargent and Lundy, Inc., consulting engineers, Chicago, to be vice-chairman of Section Seventeen, given over to the topic Coöperation of Power Producing Plants; Professor A. E. Kennelly of the Harvard Engineering School, vice-chairman for Section Nineteen, devoted to the subject Switchgear, Including Automatic Control Apparatus for Power Stations and Remote Metering and Signalling Apparatus; L. W. W. Morrow, editor of Electrical World, New York, designated as vice-chairman for Section Twenty-Three, devoted to the topic World Problems of Power Supply and Arthur L. Rice, editor of Power Plant Engineering, Chicago, vice-chairman of Section Thirty-four, devoted to the subject Education.

Chairman Merrill indicated that more than 200 engineers and industrialists, together with members of their families, will attend the World Power Conference as members of the United States party. Most of them will leave New York, June 4, aboard the Hamburg-American liner Resolute.

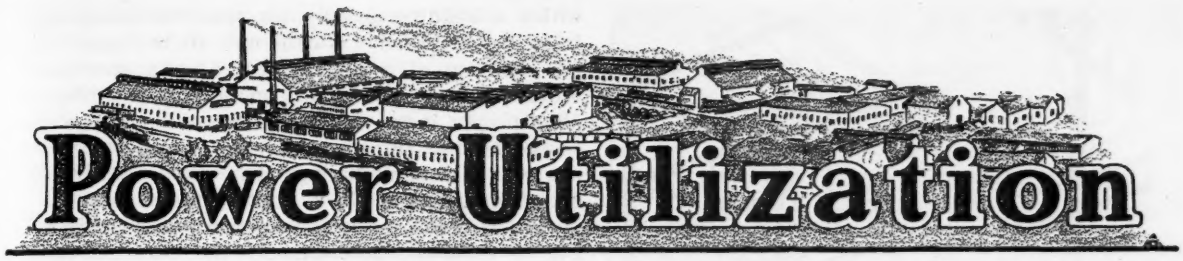
The four founder engineering societies of the United States will have official delegates at the World Power Conference to be held in Berlin, Germany, June 16 to 25 next. The names of the delegates, all leading figures in the fields of engineering education or practice, as announced by O. C. Merrill, chairman of the American Committee for the international conference are:

American Society of Civil Engineers—Arthur P. Davis of Tashkan, Turkestan; L. F. Harza and Charles W. Spooner of Chicago, Ely C. Hutchinson, George A. Orrok and David B. Rushmore, New York; W. F. Uhl, Boston.

American Society of Mechanical Engineers—Dr. Robert Sibley of the University of California; Dean Arthur M. Greene, Jr., of the School of Engineering, Princeton University; Professor A. G. Christie of Johns Hopkins University; D. Robert Yarnall, Francis Hodgkinson, Philadelphia; W. L. Abbott, W. S. Monroe, L. F. Harza, Arthur L. Rice, Chicago; George A. Orrok, Charles E. Gorton, Clifford B. Le Page, Ely C. Hutchinson, Louis C. Marburg, New York; Col. Theodore A. Peck, Victor J. Azbe, St. Louis; Dr. H. C. Dickinson, Washington, D. C.; Carl C. Thomas, Los Angeles; E. N. Trump, Syracuse, N. Y.

American Institute of Electrical Engineers—Dr. Arthur E. Kennelly of the engineering school, Harvard University; L. T. Robinson, Schenectady; Dr. Clayton H. Sharp, L. W. W. Morrow, New York; Irving E. Moultrop, Boston.

American Institute of Mining and Metallurgical Engineers—Scott Turner, Washington, D. C.; Dr. H. Foster Bain, David B. Rushmore, New York; Gustav Egloff, Chicago.



Industrial Substations—II

COSTS FOR INDOOR AND OUTDOOR TYPES. BY OTTOMAR H. HENSCHEL*

AS MENTIONED in the previous article, April 15 issue, many utilities sell and install substations. It has been found, however, that many times, when the industrial plant may so elect, it can with its own force of capable electricians and by the direct purchase of the equipment do this work itself at a considerable saving in cost; in fact, savings of from 20 to 35 per cent have been found possible.

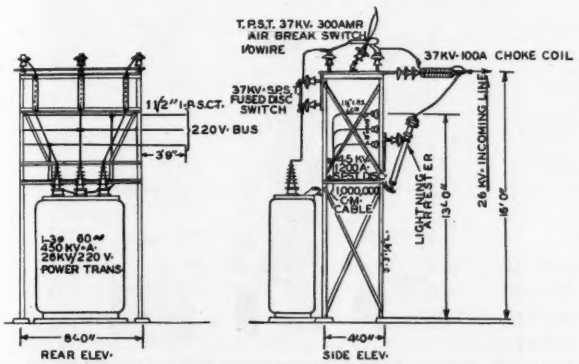


FIG. 5. 450-KV-A. STATION WITH SINGLE THREE-PHASE TRANSFORMER

It is of interest to investigate the approximate cost of an outdoor type of substation of two 200-kv-a. transformers in open delta and further to compare this cost with that of a unit of 450-kv-a. capacity, employing but a single three-phase transformer. The former appears as follows:

One steel substation structure with required grounded air-break switch, fuses, insulators, choke coils, wiring, etc.	$1134.70
Two 200-kv-a., 26,400-v. to 220/400-v., single-phase, 60-cycle, oil-insulated, air-cooled, outside type transformer having two 5 per cent taps in the primary windings at $862.00, each	1724.00
Three Pellett type lightning arresters at $74.25, each	225.75
Fencing	490.00
Concrete work	600.00
Labor (approximately)	500.00
Total	$4674.45

or, $77.85 per kw. of full 600-kv-a. rated capacity.

Let us now take in comparison a station such as shown in Fig. 5, employing a single three-phase transformer, also served at 26,400 v. and delivering energy for utilization throughout the plant at 240 v. The unit illustrated is primarily intended for secondary metering but the estimated cost here given is based on one arranged for primary metering and constructed with elevated concrete footings so as to provide the same overall height as the station employing the two (or three) 200-kv-a. single-phase transformers. We have then:

One steel structure, grounded air break switch, fuses, insulators, choke coils, wiring, etc.	$ 709.40
One 450-kv-a., 26,400-v. to 240/440-v., three-phase, 60-cycle, oil-insulated, air-cooled, outside type transformer with two 5 per cent full capacity taps below normal on high-tension side	1914.00
Three Pellett type lightning arresters at $74.25, each	222.75
Fencing	490.00
Concrete work	650.00
Labor (approximately)	500.00
Total	$4486.15

or, $99.69 per kv-a. of rated capacity.

INDOOR-OUTDOOR STATION

Local conditions frequently necessitate the employment of unusual schemes such as in the case of the installation illustrated in Fig. 6. Ground space was unavailable for an outside type of station and floor space within the plant proper, for use in conjunction with the regular inside type, proved to be at a premium. Accordingly, it was decided to build up a brick vault within the plant for the housing of the transformers (three 250-kv-a. delta connected units) and secondary switching equipment, and to erect steel work upon the roof, as shown, to carry the high-voltage (26,400-v.) switching, protective and metering equipment.

Except for the secondary control and wiring, and the vault work for the housing of the transformers, the engineer's estimate of the cost of this installation, which it practically proved to be, appears as follows, in column I:

Item	Equipment	Costs I	Costs II
(A)	Three 250-kv-a., 26,400-v., primary, 480/240-v., secondary, 60-cycle, single-phase transformers with four 2½ per cent taps below primary voltage	$2953.20	$3300.00
(B)	Three Pellett type lightning arresters with 37-kv., 100-amp. strain type choke coils	390.03	1200.00
(C)	One combination 37-kv., 300-amp., 3-pole, single-throw, vertical-break, air-break switch with all fittings and ground mechanism	344.00	500.00
(D)	Three S. & C. fuses for 37-kv. mounting	137.05	215.00
(E)	Complete structural steel roof structure	500.00	900.00
(F)	All primary (high tension) wiring	600.00	600.00
(G)	Labor	650.00	650.00
(H)	Cables, insulators, miscellaneous items including freight, cartage, liability insurance, etc.	735.00	735.00
	Total	$6309.28	$8100.00

On the other hand, quotation of the local utility was as shown in column II.

Assuming an engineering fee equal to 6 per cent of the total, in the event that the industry decides to carry on this work itself, we find that it may do this at a

*Consulting engineer, Milwaukee, Wis.

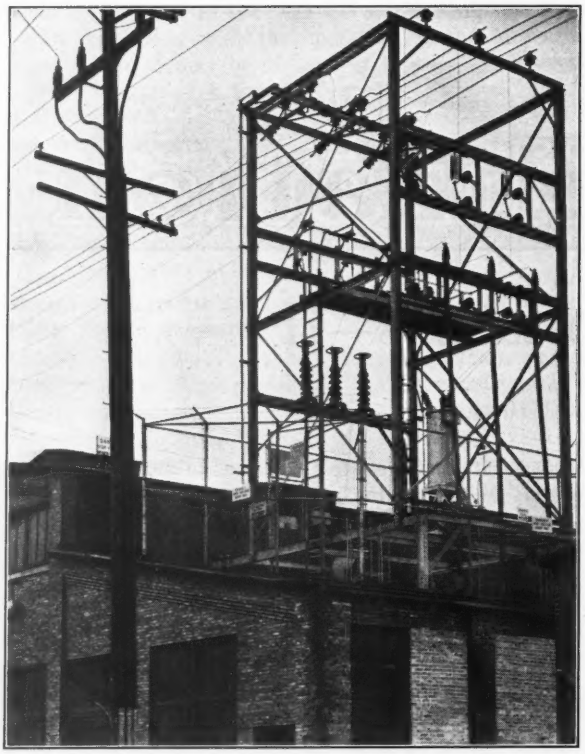


FIG. 6. WITH SWITCHING AND PROTECTIVE EQUIPMENT PLACED ON ROOF, MUCH VALUABLE FLOOR SPACE MAY BE CONSERVED FOR MANUFACTURING PURPOSES

cost of $6687.82 (the foregoing $6309.28 plus $378.54) as against $8100.00 asked for by the utility company, or at a saving of $1412.18.

Enlarging an Existing Station

Obviously, as the capacity of the installation is increased, so likewise is the size of the structure, with the addition of switching and protective equipment.

Because of expansion, the plant of a pressed steel products company was recently confronted with the necessity of increasing the quantity of energy supply available. The existing substation consisted of but a single 450-kv-a., 13,200-v. primary to 440/220-v. secondary, 60-cycle, three-phase transformer unit, housed within a building entirely too small for the purpose. Installing a second 450-kv-a. unit in the same house was then out of consideration and, as a consequence, because of the unavailability of floor space within the plant proper, it was decided to erect an outdoor station employing two transformers, each of 450-kv-a. rating but with primary windings that would readily allow changing over to 26,400 v. at any future time.

The structure proper is as shown in Fig. 7, while Fig. 8 illustrates schematically the electrical layout. The structure has an overall length of 31 ft. 6 in., a width of 13 ft. and is surrounded by a fence 17 ft. high, with an all-around clearance of 5 ft. between it and the steel work of the station. Hot dipped galvanized steel is employed throughout.

Oxide film lightning arresters, Fig. 9, are used in this installation. The energy, as stated, is delivered at the line at 13,200 volts, three-phase and, after passing through 15-kv., 100-amp. line suspension type choke coils and a 15-kv., 300-amp., three-pole, single-throw air-break switch, is carried by bus bars made up of

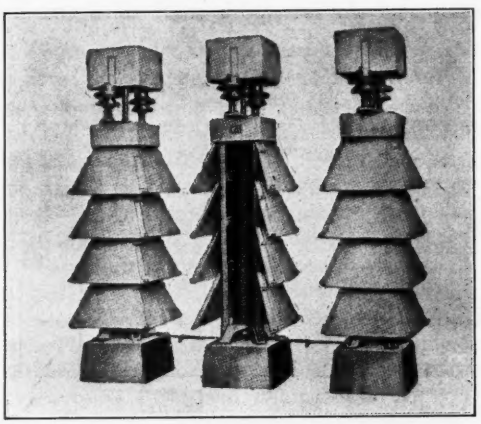


FIG. 9. OXIDE FILM LIGHTNING ARRESTERS SUITABLE FOR OUTDOOR TYPE OF SUBSTATION SERVICE

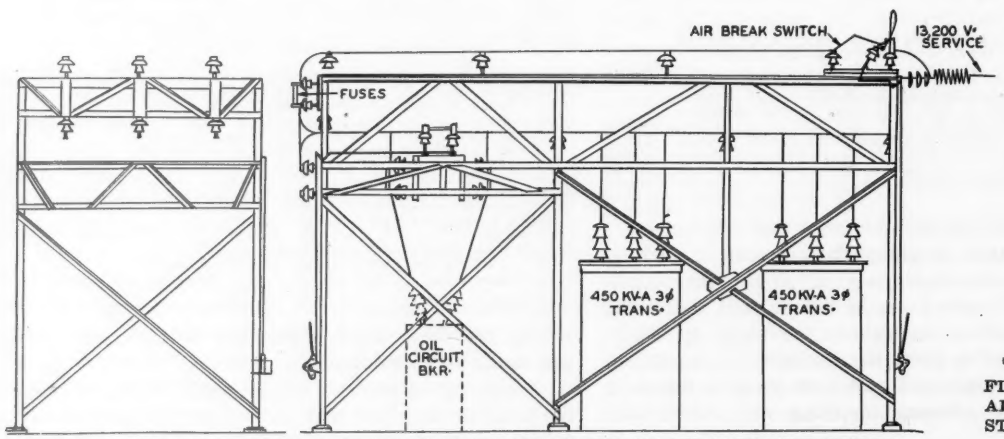


FIG. 7. OUTDOOR TYPE OF SUBSTATION EMPLOYING TWO-450-KV-A. TRANSFORMERS

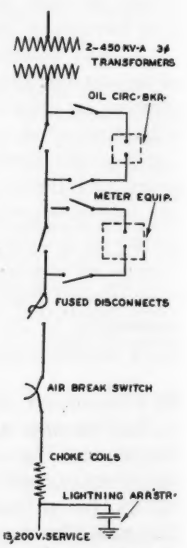


FIG. 8. SCHEMATIC ARRANGEMENT OF STATION SHOWN IN FIG. 7

½-in., hard-drawn iron-pipe-size copper tubing, placed along the top of the structure, to the detachable-hinged, fused disconnecting switches at the left. Thence it flows through the primary metering transformers, an oil circuit breaker and on to the two 450-kv-a. transformers. Disconnect switches allow the connection or disconnection of these units as required, or desired.

The main air-break switch is fitted with sleet hoods, full-floating copper contact shoes, copper blades and arcing horns, also with the necessary mechanism to allow full gang operation from the ground level.

Itemized costs of this station appear as below:

Two 450-kv-a., 13,200/26,400-v. primary, 244/488-v. secondary, 60-cycle, three-phase, oil-insulated, outside type transformers at $2714.25, each	$5428.50
One 600-amp., 1500-v., oil circuit breaker with two series trips, one shunt trip and three 80-amp., 15,000-v. current transformers	624.60
One hot dipped galvanized steel structure complete with all erection and anchor bolts	440.00
One 15-kv., 300-amp., three-pole, single-throw, vertical-break air-break switch for horizontal upright mounting and with necessary mechanism for ground level gang operation	182.30
Three 15-kv., single-pole, single-throw, detachable-hinge fused disconnecting switches for vertical mounting	132.60
Three 15-kv., 100-amp., line suspension type choke coils with strain rods and bird guards	51.75
One 15-kv., 300-amp., three-pole, single-throw, side-break disconnecting switch for oil circuit breaker bypass duty, together with all mechanism for gang operation from the ground	189.40
Six 15-kv., 300-amp., single-pole, single-throw, stick-operated disconnecting switches for isolating oil circuit breakers	161.40
Eighteen bus supports	98.10
Three 15-kv. underhung bus supports	16.35
Thirteen clamp-style copper tee connectors	21.45
Ten clamp-style copper straight connectors	18.70
120 ft. of hard drawn standard iron pipe size copper tubing	79.80
Concrete work	400.00
Fencing	635.00
Labor	550.00
Total	$9029.95

or, at the rate of $100.33 per kv-a. of rated capacity.

Indoor Station Costs

Where ample housing space already exists within a manufacturing plant, an indoor substation frequently can be installed at a lower cost than can the outdoor type, particularly if no special partitions are required to be built. In each such instance, however, it becomes necessary to provide alterations such as wired glass windows, ventilators, louvers, sills at doorways, fireproof doors and sewer drains and connections.

This may be exemplified in the case of a 900-kv-a. station comprising two 450-kv-a. transformer units with necessary switching and protective equipment. The cost of such an installation may be:

Two 450-kv-a., 13,200-v. primary, 240/480-v. secondary oil-insulated, transformers, at $2042.98 each	$4085.96
One three-phase, 15,000-v. indoor substation type of oxide film lightning arrester	331.00
One 600-amp., 15,000-v. oil circuit breaker	624.60
Necessary disconnect switches, bus bars, structures, etc.	750.00
Building changes	500.00
Labor	475.00
Total	$6766.56

Except, then, for actual building costs this would be equal to $75.18 per kv-a. of rated capacity.

Societe Generale de Production d'Electricite of Antwerp, Belgium, has lately placed a contract with the Siemens-Schuckert Works Co. of Berlin for a 60,000-kw. turbine-generator set for the power station at Schelle. The turbine will be of the Roder type and will use steam at a pressure of 35 atmospheres (500 lb. per sq. in.) and a temperature of 425 deg. C. (about 800 deg. F.). The set will run at 3000 r.p.m. and will generate power at 10,500 v.

Compressed Air System Explosion

Too Much Oil on a Hot Day Caused Disaster. By E. O. Edney

FEW ENGINEERS realize the danger of an air tank explosion. The writer himself did not realize it until one afternoon in August when the weather was very hot and the temperature of the cooling water used

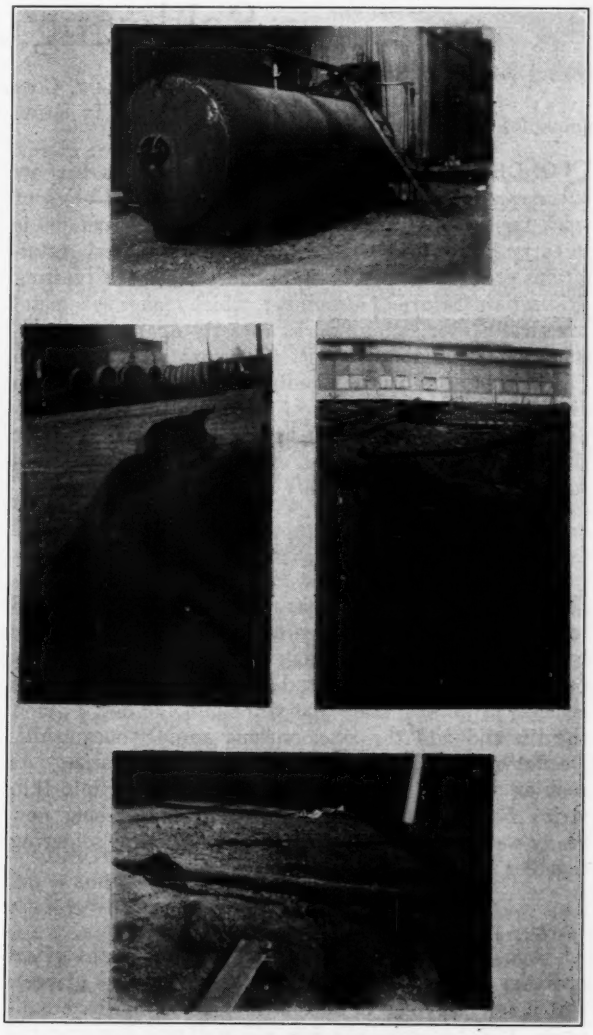


FIG. 1. AIR TANK SHIFTED ON SADDLES
FIG. 2. 5-IN. PIPE BLOWN OUT OF GROUND AND SPLIT
FIG. 3. PIPE WRECKED A MILE FROM THE COMPRESSOR
FIG. 4. BRANCH LINES LOOKED LIKE THIS

on a large cross-compound, two-stage compressor was 80 deg., which made it necessary to use a large quantity of oil in the air cylinders.

On this afternoon, while the compressor was running about 40 per cent faster than it should, with a rumble like a tornado and followed by a report and trembling of the earth much like an earthquake, the compressor came to a stop. On examination of the recording air gage on the compressor, it was found that the pen had gone off the chart past the range of the gage which read up to 200 lb. How much pressure was

placed on the gage no one knows, but the combination speed and pressure governor did its work and stopped the compressor.

I rushed to the throttle and closed it, then went to the door and looked at the air storage tank, Fig. 1, which was not damaged but was almost red hot and shifted in its saddles about 12 in. The 5-in. pipe which supplied the entire shops with air was blown out of the ground, Fig. 2, as far as I could see and all of the branch pipes were broken loose. The pipe line which was about a mile long was all blown out of the ground and opened up like a tin can. Figure 3 shows a piece of pipe almost a mile from the compressor and Fig. 4 some smaller branch pipes.

Fortunately no one was injured, as it so happened that no one was near the pipe line when the explosion came but no chances will be taken again with excess oil in the compressor cylinder at high temperature.

Soldering Aluminum

SPECIAL FLUX, CORRECT SOLDER AND PRACTICE MAKE IT EASY. BY PHILIP N. EMIGH

SOLDERING TWO aluminum cables together by means of a sleeve joint may be a difficult piece of work for the uninitiated, especially if the finished job is to carry heavy overloads, as almost all electrical installations are called upon to do at times. The self-limiting oxidization feature of aluminum, which makes this metal practically everlasting, works directly against the person attempting to solder it. This oxide of aluminum (Al_2O_3) or alumina is rapidly formed by exposure to air and the first principle of successful aluminum soldering is that the parts to be joined together must be thoroughly cleaned without exposure to the air. This sounds difficult but in reality is quite easy.

FLUX AND SOLDER

At the drug store, get a few ounces of stearic acid. This is a substance that looks and smells like tallow and has the faculty of melting at moderate temperatures but not evaporating. This will be our flux. Get one part, by weight, of zinc and four parts of tin. In a crucible or an iron ladle that will stand 420 deg. C. melt the tin and add the zinc, stirring rapidly meanwhile. Do not overheat, as the zinc will rapidly vaporize. As soon as the zinc has melted, pour the mixture into thin strips for ease in handling. Our material being now ready we will try a simple proposition, that of soldering together two flat strips of aluminum.

A SIMPLE JOINT

Heat one of these aluminum strips by means of an ordinary tinned soldering copper or any source of heat. Cut a few shavings of flux and sprinkle on the aluminum. If hot enough, the flux will melt and flow over the surface. Next, with a knife blade or any small tool, scrape or score the surface to be soldered, making sure the flux is still melted. By this method the oxide is thoroughly removed and none can form because of the protective coating of flux. Even if the aluminum now gets cold, the surface is protected.

Next, touch the tinned soldering copper to a stick of the special solder (tin and zinc) and a drop will adhere, as for tinner's solder. Press the bit firmly onto the aluminum, giving it a rotary or sliding motion and as soon as the metal is heated, the solder will flow over the surface like regular solder on a piece of copper. The excess flux is wiped off and the aluminum is now properly "tinned" and ready for the rest of the operation, which consists of pressing down on the other piece of "tinned" aluminum and applying heat. As this solder has rather a high melting point, more heat is necessary than for ordinary solder. For this reason it is usually necessary to tin the bit after each aluminum soldering job.

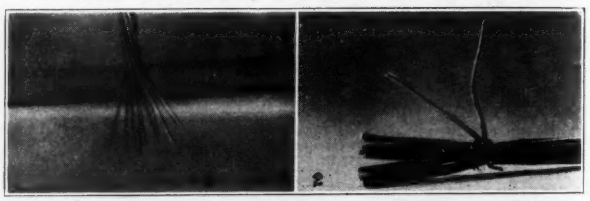


FIG. 1. SPREAD THE STRANDS AND TIN EACH ONE SEPARATELY
FIG. 2. PROPERLY TINNED STRANDS HAVE POLISHED APPEARANCE

CABLE AND TERMINAL

We will now turn our attention to a more difficult piece of work, that of soldering an aluminum cable into a copper terminal. Open up the end of the cable, exposing each individual strand. Scrape these fairly clean for about two inches. Heat one strand in the flame of a blow torch, thrust into a cake of flux, scrape away the oxide as previously explained, heat again if necessary, apply more flux and rub with solder which will immediately flow smoothly down the wire. Figure 1 shows the cable opened up, with two strands in the foreground properly tinned. These are more clearly shown in Fig. 2. Attention is drawn to the bright, polished appearance of these strands as compared to the balance of the cable.

Tin the balance of the cable strands and heat slightly, wiping off all surplus flux, after which the strands are pressed back to shape so that the cable will enter the terminal, which has been tinned with ordinary solder and flux. Nearly fill the heated terminal with tinner's solder and insert the cable. Feed solder to the joint as it is absorbed and, when filled, remove the torch.

As aluminum is a first-class conductor of heat, particular attention should be paid to the distance the heat travels up the cable as this is the guide to the amount of heat to be applied to the next job. Figure 3 shows two views of the finished joint, aluminum cable to copper terminal. Particular attention is drawn to action

of the solder in the interstices of the cable, how it has flowed up by capillary attraction. This is a very good joint on which to practice as the action of the solder can be watched throughout the operation and confidence established.

Sleeve Joint

Joining two aluminum cables by means of a sleeve is no more difficult than the last job except that the progress of the heat and solder cannot be seen. By now, however, the workman should know, by the feel

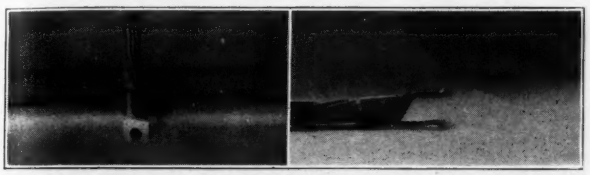


FIG. 3. KEEP CABLE AND TERMINAL HOT UNTIL FILLED WITH SOLDER

of the cable and by the amount of solder fed to the joint, just what the interior conditions are. The ends of the cable are treated as in Fig. 1. When properly tinned, the ends are thrust into the copper or aluminum sleeve, which has a small hole bored in it at the center. If an aluminum sleeve is used, it must be tinned with the aluminum solder and the flux wiped out. Care must be taken that the aluminum sleeve or any aluminum work is not overheated, as this will destroy the tinning and a new coating will be necessary.

The ends of the sleeve and cables are taped up to prevent loss of solder, leaving an open space at the

FIG. 4. SOLDERING CABLE INTO SLEEVE USES THE SAME METHOD

center as shown in Fig. 4. If asbestos tape is not available, several layers of friction will do nicely. Apply heat to the central portion of the joint and feed solder. When the sleeve is filled and the heat has traveled back up the cables (sometimes two or three feet) withdraw the torch and the job is completed.

Copper and aluminum cables may be joined as in Fig. 2 by tinning the aluminum cable, then proceeding as if both cables were copper. The writer of this article, in 1915, soldered several 1,000,000-cir. mil. aluminum cables into brass terminals and, at last accounts in 1926, they were still in service in a substation supplying power for a street railway system and carrying the usual overloads with no signs of distress.

Blowholes, quite common in aluminum castings, are easily filled with this solder and a leaky stew kettle is as easily repaired as the commonest tin pan. Aluminum alloys are soldered by the same method, since the troublesome oxide is still present although in a weak form.

Belt Length Easily Figured

By W. F. Schaphorst

HERE ARE SOME handy kinks and rules pertaining to belting which, so far as I know, are new. They are the result of my own study of belt problems.

It is well known that belt contact on the "small" pulley is usually most important, because there is invariably less belt wrap on the small pulley than on the large unless a wrapper pulley is used.

Where R = radius of large pulley in inches.
r = radius of small pulley in inches.
L = distance between centers of shafts, inches.
(R — r) ÷ L = Sine a (see Fig. 1).

Looking into our trigonometry, we find the following values for sines:

Angle deg.,	1	10	20	30
sine	0.017452	0.173648	0.34202	0.50000

Now, dividing the number of degrees by its sine, we find that the quotients ranging from 1 deg. to 30 deg. are nearly constant, varying only from 57.5 to 60, with an average of 58.

Angle deg.,	1	10	20	30	Average
Angle ÷ sine	= 57.5	= 57.7	= 58.2	= 60.0	58

This means, in the case of belted pulleys with the arc of belt contact varying from 180 to 120 deg., that there is not much change in the intermediate sines. Hence the following formula will give sufficiently accurate results for any ordinary belt drive up to the point where the angle a equals 30 deg. and even beyond 30 deg. it will not be far wrong, because where a is as much as 45 deg. we would have the quotient 63.7 instead of 58. It seldom happens, however, these days that an arc of contact as small as 120 deg. is allowed.

In view of the above, we can now proceed as follows:

$$\text{Sine a} = a \div 58 \text{ (approximately)}$$

Substituting in the formula above,

$$(R - r) \div L = a \div 58$$

$$\text{Whence } a = 58\ (R - r) \div L$$

But the number of degrees of belt contact is: $180 - 2a = 180 - [58 \times 2\ (R - r) \div L]$.

Since pulley diameters are usually given rather than radii, we can convert this into the most convenient form:

$180 - [58\ (D - d) \div L]$ = degrees of contact.

Where D = diameter of large pulley and d = diameter of small pulley.

Converting this formula into words or into "rule form" for those who do not like to bother with formulas, the rule is:

Subtract the diameter of the small pulley from that of the large pulley in inches; divide by the inches distance between centers; multiply by 58 and then subtract from 180. The answer is best contact angle in degrees and assumes that neither side of the belt is slack.

Length of Open Belt

After developing the foregoing, I stumbled onto the fact that angle A of the small pulley, Fig. 1, is always equal to angle B on the large pulley and that angle C is always equal to angle D. This being the case, it is possible to use the preceding rule for determining belt

lengths more accurately than is obtainable by means of any other empirical formula of which the writer has knowledge—more accurate than any rule that does not involve the use of the angle, the sine of the angle, or the cosine of the angle. In other words, it eliminates trigonometric functions.

Without taking up the space to develop the formula in detail although, should any reader wish to do so, it can be rationally developed from the foregoing, the resulting formula is this:

$$\text{Belt length in inches} = [3.14\ L\ (D + d) + (D - d)^2 \div 2L] + \sqrt{4\ L^2 - (D - d)^2}$$

Where D, d, and L are the same as above in inches.

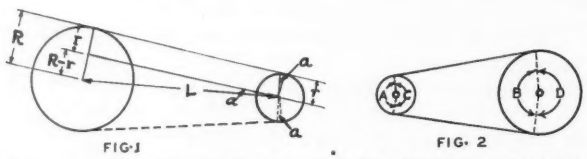


FIG. 1. RELATION OF BELT CONTACT ANGLE TO PULLEY DIAMETERS AND DISTANCE BETWEEN CENTERS
FIG. 2. RELATION OF CONTACT ANGLES AND OPEN SPACE ON PULLEYS

Applying this formula to a drive in which there is considerable difference in diameter and in which the distance between shaft centers is short, namely: D = 50 in.; d = 10 in.; L = 60 in., it will be found that the length of the belt is 220.5 in.

Applying the exact formula, with trigonometric functions, gives 220.6 in. as the exact answer. In other words, the difference is only 0.1 in.

For belted pulleys with the arc of contact on the small pulley varying from 180 to 120 deg., the preceding formula will give sufficiently accurate results.

Dollars and Sense Steam

DOES THE AVERAGE engineer always stop to consider that nearly every form of energy scattered around the plant is in reality just so many dimes, quarters and dollars? No conscientious fireman would intentionally shovel a five dollar bill into the fire box but many a fireman dumps the equivalent in perfectly good coal into the ash pit by improper manipulation of stokers.

I have seen a fireman labor and sweat to hold the pressure on his boilers and then leave the blowoff wide open while he took time to advise a friend on the logical stock to buy for big returns. The same fireman who wastes a dollar's worth of steam is an entirely different individual when it comes to looking over the wife's grocery bills.

It is also true that an engineer may be trying his level best to keep down costs yet be missing a good many leaks. A technical training is an asset and undoubtedly develops a questioning attitude and an ability to analyze and draw conclusions but common sense and a desire to get the facts are likely to yield as much if not more fruit. If you do not know whether a certain engine is a "hog" on steam, get in touch with the makers and learn how to find out. You do not need a diploma to take indicator cards and you will be surprised to learn how willing manufacturers of your equipment are to help you. They know that it is poor policy to have their product operating inefficiently.

Another thing, just because you happen to be doing a thing a certain way and, to the best of your knowledge, it has always been done that way, don't take it for granted that it is the most efficient way.

I have heard engineers say that, if they had a feedwater heater, economizer and other equipment, they could make a showing. Such statements usually indicate lack of initiative or endeavor to get better results with present equipment. It has been my experience that nothing pleases an employer so much as to find a man who is out to cut costs without crying for a big expenditure for new equipment.

True, often new and modern equipment is needed to get results but I have never yet seen a plant in which economies could not be effected without first spending a lot of money.

If you have charge of steam using, find out what a pound of your steam costs. Think of it in terms of dollars and cents and recognize your obligations to see to it that no one steals or wastes it.

It is so convenient to use a steam hose for washing floors or blowing out a dirty piece of equipment. You can easily ascertain what it costs to blow steam to atmosphere through a ½-in. opening. It might surprise you. Don't forbid the use of steam for some apparently costly operation unless you can suggest a cheaper alternative, because the man who is thus toying with your protege will undoubtedly ask you how to do the job without using steam.

I have in mind a problem which I solved along these lines. It was necessary to remove seepage water from a concrete pit in order to protect a motor-driven pump located at the bottom of the pit. A steam syphon was installed, and worked beautifully 24 hr. a day, seven days a week. The problem was solved.

A few figures plainly showed that it was costing more to keep that pit dry than it was to operate the pump which was protected from submersion. Pump salesmen coöperated with us to the extent of advocating the installation of a float-controlled pump in place of the steam syphon. Their figures proved conclusively that cost of operation would be much lower. Why should we hesitate? First, the pump cost $300—and we needed that money.

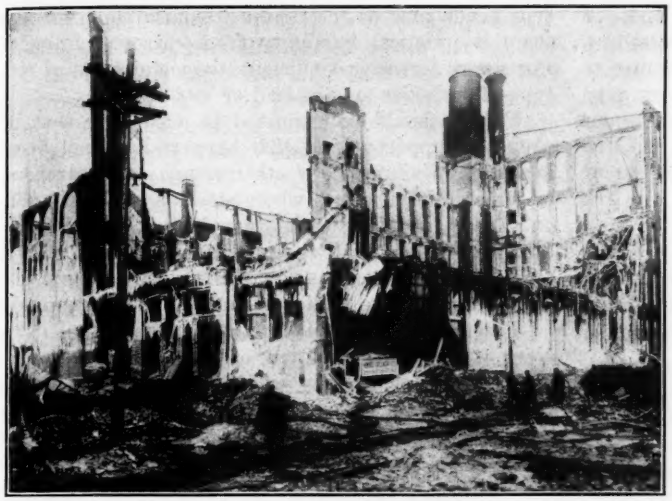
The problem was solved by installing a water eductor costing $16 in place of the steam syphon. Fortunately, high-pressure water was available at small cost. There is always more than one way to "skin a cat."

Moreover, always bear in mind that it is your cat and that a pound of steam or a kilowatt of "juice" is just as much real money as the crisp new dollar bills which your employer tucks in your envelope every pay day.

If you are in charge of steam, look on it as your employer's money with which you are entrusted. You will be surprised at the number of nickels and dimes which you have been allowing to go "down the river" and, if I am not mistaken, you will be greatly pleased to learn that your efforts have been appreciated.

Lincoln, N. H. A. P. NUTTER.

NATURAL GAS storage is not practical, therefore some standby fuel, usually oil, is always installed where continuous service is necessary.



Watch The Automatic Sprinkler System

SPRINKLER EQUIPMENT WAS NOT INSPECTED AND MAINTAINED TO INSURE PROPER FUNCTIONING. CONSEQUENCES FOLLOWED AS ABOVE. BY WARREN L. WILMARTH*

THIRTY BILLION DOLLARS is the approximate value of property protected from fire by automatic sprinklers. Practically all classes of property are represented and the importance of careful maintenance of automatic sprinkler equipments is emphasized by the values at stake.

It is the function of the fire protection engineer so to design automatic sprinkler systems that they will properly and completely protect all portions of a plant, thus securing the most favorable insurance rates. The installing company is obligated to follow the plans of the fire protection engineer and complete the work to the satisfaction of the owners as well as that of the insurance interests which are financially interested in proper fire protection. After the equipment is installed, it is the duty of the owner to see that the automatic sprinkler system and the water supplies are properly maintained as insurance policies specify that due diligence must be exercised.

No other mechanical equipment receives less care, as apparently relatively few plant officials realize the importance of careful maintenance of this fire protection equipment. When it is considered that the physical property, the conduct of business and the lives of employes are all jeopardized by failure to have the sprinkler systems in good working order, it is obvious that greater care will increase plant safety.

Since maintenance of sprinkler systems is entrusted to persons ranging from the expert maintenance engineer or master mechanic in large plants to the janitor or custodian of small buildings, the larger sprinkler companies, recognizing the importance of proper upkeep, maintain their own inspection forces to coöperate with and assist property owners' employes in maintaining real preparedness for fire. These experts not only check maintenance conditions periodically but also instruct employes in the care necessary for proper operation.

Our own company, for many years, has obtained satisfactory results and maintenance of sprinkler systems has been greatly improved in properties which are regularly inspected. During the past year, inspectors found 36 closed gate valves with automatic sprinkler protection seriously impaired or wholly lacking. In the past 11 yr., a total of nearly 72,000 sprinkler system maintenance defects have been reported to property owners, who have thereby been enabled to make corrections which have improved protection or prolonged the useful life of this equipment.

TYPES OF AUTOMATIC SPRINKLER SYSTEMS

In general, automatic sprinkler systems are divided into two classes, wet pipe and dry pipe. As the name implies, wet pipe systems are those in which the piping

FIG. 1. THIS VALVE GIVES WARNING OF TROUBLE

*Inspection and Service Dept., Grinnell Co., Inc.

is always full of water, ready for action when heat from fire opens the sprinkler. Dry pipe systems are those in which, because of exposure to freezing temperatures, the water is kept back at a point near the entrance to the building by a special unit known as the dry pipe valve, the piping system being filled with air under pressure. When an automatic sprinkler is opened, the air pressure is reduced, which causes the tripping of the dry pipe valve to permit the flow of water to the opened sprinkler.

Dry pipe valves are so designed that an air pressure substantially less than the normal water pressure is sufficient to keep the valve closed. In practice, an air pressure somewhat higher than one-sixth of the normal

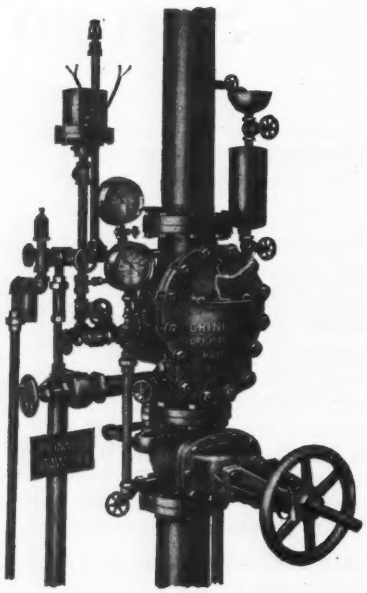


FIG. 2. DRY PIPE VALVE TO HOLD BACK THE WATER UNTIL NEEDED

water pressure is maintained in order to take care of surges or hammer in the water mains. As an example, it is customary to maintain from 25 to 35 lb. air pressure on the system side of a dry pipe valve for a maximum water pressure of 100 lb.

Wet pipe systems act practically instantaneously, while the dry pipe system is somewhat slower in getting water to the seat of the fire. An attachment known as an accelerator has been developed for quickly removing the air from dry pipe systems. With this device in proper operative condition, the speed with which water reaches the fire is practically the same as in a wet pipe system.

Inspection of Systems

Proper maintenance of either wet or dry pipe systems requires an occasional examination of the automatic sprinklers, the piping, hangers, alarms, water supplies and gate valves. Under normal conditions, the sprinkler heads require little attention but the older solder type sprinklers are subject to corrosive action from acid fumes and severe atmospheric conditions. Where such conditions exist, it is advisable to see that corrosion has not attacked the solder, which holds the moving parts in place until they are fused by heat. With the new type heads such as the Grinnell Quartz Bulb sprinkler, there is practical immunity from corrosive influences. For severe corrosive conditions, the metal parts of either type of sprinkler may be lead or wax coated.

Piping should be examined to make sure that it is properly supported and that hangers have not become loosened by vibration or other causes. In warehouses, stores and other places where stock is piled in bulk or on shelves, it is important to note that such materials do not interfere with the proper distribution of water from sprinklers, or cause sagging of the floors which may put an undue strain on piping and hangers below.

Practically all sprinkler systems are installed with alarm valves, the function of which is to sound an alarm either electrically or by flow of water through the water motor of a rotary gong. It is advisable to test such electric and rotary gongs at frequent intervals in order to be sure that an alarm would be given in case of fire. Such tests are seldom necessary more often than once a week and usually thirty-day intervals give proper assurance of the operative condition of the alarms. Suitable testing connections are provided for this purpose.

Care of Dry Pipe Systems

In addition to the tests mentioned above, dry pipe systems require additional attention to ensure proper operation. It is necessary to maintain the air pressure above the dry pipe valve within proper limits. Too little air pressure is likely to cause the dry pipe valve to trip, particularly in locations where there is considerable surge or water hammer in the city mains. On the other hand, it is inadvisable to carry the air pressure above the limit prescribed by the manufacturer because a longer time will be required to reduce the air pressure to a point where it will allow the dry pipe valve to trip. This would result in greater spread of fire before water reaches the opened sprinklers.

Proper amount of water should be kept in the priming chamber of the dry pipe valve and any slight leakage past the seat of that valve or water from condensation above the valve should be removed at frequent intervals. Special attention should be paid during the winter months to the removal of condensation water which may have accumulated at low points in the dry system, if there are portions of the piping which are so located that they will not drain back to the main riser.

Accelerators attached to dry pipe valves require little attention but occasional test is advisable to ascertain whether this unit is in good working order.

Water Supplies

In general, sprinkler systems are connected with city mains which provide an adequate pressure, usually 15 to 25 lb., on the highest line of sprinklers. In some cases, where pressure is insufficient or volume of water available inadequate, it is necessary to augment the supply from the water works mains by one or more gravity or pressure tanks, or fire pumps.

Where such supplies are necessary, proper maintenance requires that the water in tanks be kept at a temperature of at least 40 deg. F., so that there is no danger of freezing. With gravity tanks, this is usually

accomplished through the use of tank heaters especially designed to fulfill this purpose in an economical manner. Pressure tanks are generally located within the building or on the roof and enclosures must be heated sufficiently to prevent freezing. The proper air pressure in the upper part of the pressure tank and the water levels in both gravity and pressure tanks should be maintained as required, in order to have adequate water available for fire extinguishment.

When fire pumps are used as a supply for sprinkler systems, they should take suction from reservoirs or streams of ample capacity. The strainer on the suction line should be frequently examined and kept free from leaves, rubbish or sand to prevent injury or clogging of the sprinkler piping. Steam pumps should always have available an adequate supply of steam at proper working pressure. With electrically driven pumps, it is advisable to have current obtainable from two sources,

FIG. 3. SOLDER TYPE OF SPRINKLER HEAD

FIG. 4. QUARTZ BULB TYPE SPRINKLER HEAD

if possible, each carefully installed with underground connections, if feasible, in order to prevent interruption to service. Both steam-driven and electrically-driven pumps should be started up or turned over at least once each week to be sure that they are ready for operation.

Gate Valves

It is of vital importance that water from the sprinkler system be available at all times. For this reason, it is necessary to pay careful attention to gate valves controlling the supplies and these should be fully open at all times. One suggested method is to have gate valves securely fastened in the open position, using straps and padlocks for this purpose to prevent interference by unauthorized persons. In emergencies, should it become necessary to close a valve so fastened, the strap may be cut or broken. Gate valves should be inspected at least weekly and a written report of their condition kept on file.

Sprinkler System Supervisory Service

In the larger cities, owners of sprinkler systems may avail themselves of a service known as Sprinkler System Supervisory, which maintains a constant watch over the various parts of the sprinkler system. This embodies a system of electrical connections to each gate valve, alarm valve, dry pipe valve, tank and pump with a direct connection to a central station. Employes are always on duty to receive an alarm, in case water flows in the sprinkler system due to fire or other causes. The devices installed on the tanks not only give notice in case the water level is changed beyond the proper limits but also give warning when the temperature in these tanks goes above or below a definite range.

Where this supervisory service is installed, owners receive immediate notification of trouble with the sprinkler system and a runner is dispatched to the property.

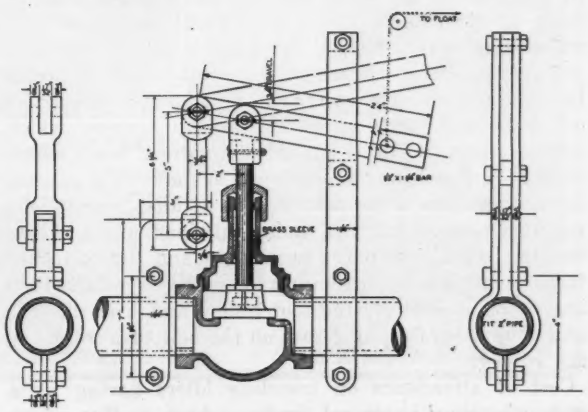
Need for Careful Maintenance Shown by Records

Because automatic sprinkler systems are infrequently called on for action, they are often overlooked and sometimes entirely forgotten. The records kept by the National Fire Protection Association indicate that in practically 75 per cent of the fires which are not satisfactorily controlled, the automatic sprinklers failed to function properly because of careless maintenance. The chief reasons given are closed valves, portions of the property not protected by automatic sprinklers, defective water supplies, improper maintenance of systems and obstructions to distribution. All of these conditions can be prevented, if proper attention is paid to careful, systematic maintenance of the sprinkler equipment and supplies.

If all automatic sprinkler systems are kept in good working order at all times, there will be a marked reduction in the fire losses in sprinklered properties which will undoubtedly react to the benefit of the owners who are paying the premiums on the thirty billions of insurance.

Float Valve Made from Old Globe Valve

Here is an illustration of a float valve constructed from an old globe valve which has given entire satisfaction and can be made at slight expense. The drawing



FLOAT VALVE MADE FROM OLD GLOBE VALVE

with dimensions is practically self-explanatory. The valve was constructed to be operated from the float in a tank above, the cable to the float running from the end of the lever.

Lincoln, N. H. A. P. Nutter.

Industrial Conveyor Maintenance

RELIABILITY INCREASED BY PROPER MAINTENANCE. ANTIFRICTION BEARINGS, FORCED LUBRICATION AND SPEED REDUCERS ARE PROTECTIVE AGENCIES

MAINTENANCE cost is in many cases one of the lesser items making up total cost of operating conveyors of all kinds. Importance of proper maintenance rests mainly in securing greater reliability of performance, fewer shutdown periods and lesser requirement of personal attention.

Conveying equipment is in many cases exposed to the elements and has frequently experienced lack of care, maintenance of conveying machinery, therefore, has not received the attention due its importance and not only lowered efficiency but great loss of production has resulted.

Among the outstanding changes now occurring in conveyor design are the use of roller and ball bearings and the application of pressure lubrication. Another feature is the use of speed reducers in the driving mechanism. Antifriction bearings not only reduce the required operating power but effect reduction in attendance. Pressure lubrication prevents dust, which frequently accompanies material movement from working into the bearings.

Most belt troubles occur because of lack of care in placing the belt on the conveyor resulting in injury to the cover or edges; crooked splicing which causes the belt to run unevenly and wear at the edges; charring or burning of holes due to handling material that is too hot; handling materials that corrode the cotton or soften the rubber, causing the plies to separate; incorrect installation of skirt boards which cause cutting of the belt; loading directly over idler which causes belt to be cut; operation at too high speed which prevents lumps of material from being picked up properly and cut the belt or cause the thin load to wear the belt in the center; too small pulleys which cause plies to come apart; troughing too steep for thickness of belt which may crack the belt or cause it to run crooked; too great distances between idler pulleys which causes belt to crack longitudinally; bad alinement which causes edges to be worn; excessive take-up tension which stretches belt and pulls out splices; reverse bends which tend to pull belt apart; exposure to snow, rain or sunlight which decays the rubber; lack of idler lubrication; repeated sudden starting under full load which causes belt to stretch and splices to pull out and slip to injure the belt surface and dropping of lumps on return belting which jam under the foot pulley and tear the belt and dropping of oil or grease on the belt thus softening the rubber.

Cost of attendance on traveling idlers having plain grease bearings is several times as much as that where antifriction bearings are provided. Wide belts can be run at faster speeds than narrow belts because the wider the belt, the deeper the load and the less material proportionately that comes in direct contact with the belt surface to cut and abrade it. A short belt wears out faster than one that is long because each foot of surface passes the loading point more frequently.

Where buckets are fastened to a belt, gritty material may be prevented from getting under the buckets, thus cutting the belt, by fastening triangular strips to the belt just back of each bucket. Regular inspection will reveal loosened or broken bolts which should be tightened or replaced. If belt holes become worn, it is best to shift all of the buckets to new positions by punching new holes in the belt.

It is advisable to paint the ends of the belt with rubber cement before splicing it in order to prevent penetration of moisture. The belt is the most costly item in a belt conveyor and at the same time the most vulnerable part. If it receives good care, it will serve cheaply but if permitted to be damaged or ruined by any of the causes stated above, the repair or renewal charges may be excessive. One characteristic advantage of the belt over the chain conveyor is the evidence of wear which is indicated long before actual break occurs, thus avoiding shutdowns without warning when regular inspections are made.

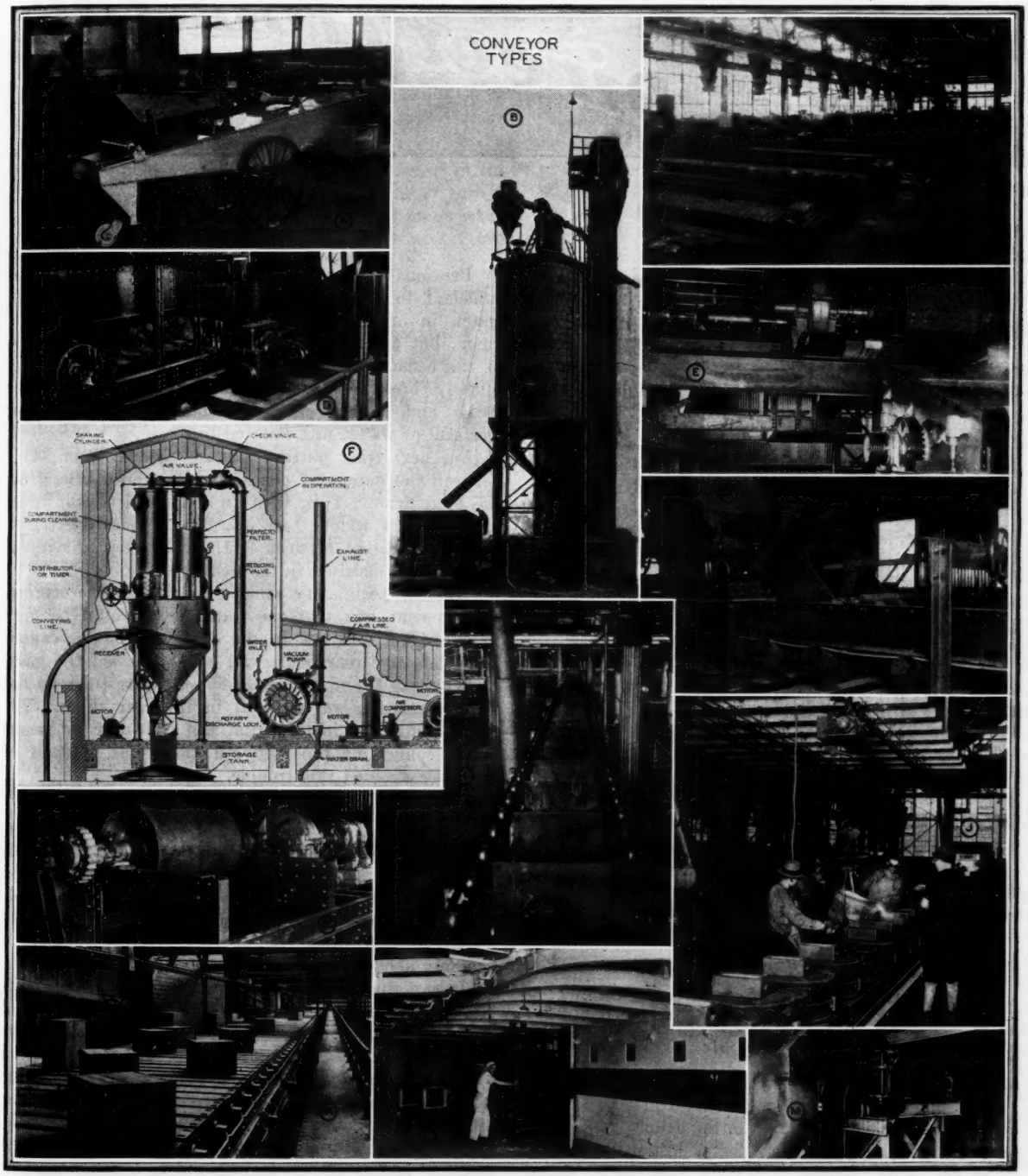
Proper lubrication of moving parts and regular attention to the terminal mechanism of conveyors, which usually consists of gears, chain drives or speed reducers, should be provided. In most chain conveyors, lubrication requires the greatest attention from the inspection service. In those forms of chain conveyors that employ plain links sliding in metal guides, low power consumption requires the tracks to be well greased. Inspection of chain conveyors will show that renewal of a few worn links and occasionally of broken rollers on belt or gravity conveyors will add years to the functional life of the equipment. Steel aprons are used on apron conveyors where the service is severe such as in handling metal scrap.

Especially where operation depends upon the free movement of rollers on their journals as in gravity roller conveyors, use of ball or roller bearings that are protected against corrosion is important as congestion would result from failure of a few rollars to rotate. In certain situations such as in dairies where the equipment is subject to the effects of steam, water, milk and salt which are all more or less corrosive, it is important to use rollers that are amply protected.

Steam jet conveyors, being low in first cost and maintenance cost, find wide application in moving dusty materials where operation is intermittent during short periods of time. Use of dry steam avoids corrosive action. In the hydro-jet conveyor where considerable water is used, the wear on straight horizontal runs in high velocity sluiceways is almost negligible.

In pneumatic conveyors used for loose material, the induction of a circular motion by tangent admission accelerates the separation of heavy particles and reduces abrasion by the materials held in suspension. Repairs and renewals of parts at the intake are facilitated by bolting a removable wearing plate of steel to the flattened side of the intake.

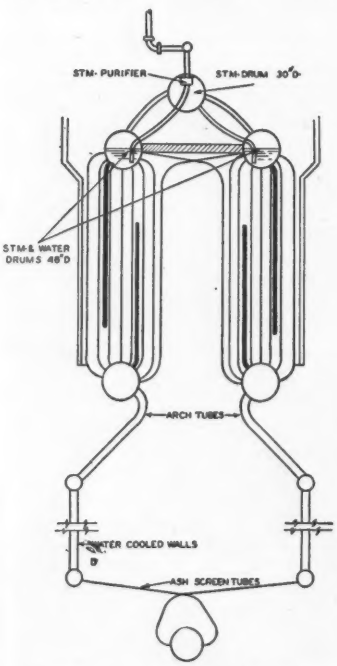
Many Types of Conveyors Serve Industry



A. Portable belt conveyor has wide application but often receives rough handling. Belt protects driving mechanism. B. Pneumatic conveyor and vitrified-glazed-tile storage tank used for handling irritating materials such as soda ash and lime. C. Sand preparation and mold-handling roller conveyor serves foundry. D. Belt feeder with motor driven speed reducer drive. E. Feeder with variable-speed and herring-bone gear drive delivers bulk material at rates varying from 50 to 350 t. per day. F. Dust is removed and air is filtered by pneumatic means. G. Attention to gearing on heavy feeders reduces power requirement. H. Belt elevator is driven by motor through gear reducer and is provided with holdback to prevent reversal of movement on incline. I. Flight conveyor distributes sand in foundry. J. Process of pouring molten iron is aided by mold conveyor. K. Wood-slat apron conveyor serves shipping department. L. Monorail conveyor aids in making good things to eat. M. Motor drives operating through geared speed reducer are well protected against dust and grit and provide means for ample lubrication.

Baffle Change Reduces Moisture in Steam

ELIMINATION of moisture in the steam generated by our boilers when operating at rates of 25 lb. evaporation per sq. ft. of boiler and furnace heating surface



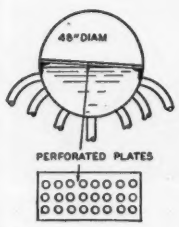


FIG. 1. ORIGINAL ARRANGEMENT OF BOILER
FIG. 2. PERFORATED PLATES AS APPLIED TO THE DRUMS

with 90 per cent chemically treated makeup water or at least its reduction was necessary at our plant.

Our boilers were of the type shown in Fig. 1. Several types of baffles were tried in the drums, which were 48 in. in diameter, including the deflection and louver types and those designed to remove moisture by changing the direction of flow but all failed. Finally baffles composed of perforated plates, placed in the drums at an angle, as shown at Fig. 2, were tried and found to operate successfully.

With this baffle in place, the calorimeter temperature remained practically constant at ratings up to 22½ lb. of water evaporation per sq. ft. of heating surface and the moisture was found to be less than 0.5 per cent.

Previous to the installation of this baffle, it was sufficient to blow down the boilers once during each watch in order to keep the concentration below 200 r.p.m. but after drier steam was obtained by the use of the baffle, it was necessary to blow down more frequently because less impurities went out with the steam and finally continuous blowdown, which was wasteful of water, was resorted to.

We next tried putting a plate with a $\frac{5}{16}$-in. orific between the flanges of one of the blowdown lines from the mud drum. This, with an occasional blowdown at all valves, of which there are 13 on each boiler, kept the concentration between 220 and 250 p.p.m. without effecting the moisture in the steam.

Another peculiarity which developed in the original arrangement was that the water level would be high in one drum and low in the other. This was caused by a defective rear baffle wall which allowed the gases to bypass to the uptake and kept the rear tubes so hot that circulation was reduced in the rear tubes. The water would rise in the drum and pass over by means of the connecting pipe between the drums. Repair of the baffle avoided this trouble.

New York City. THOMAS SHEEHAN.

Superheater Maintenance

STEAM SUPERHEATER tubes are generally constructed of mild steel. This metal, while possessing considerable strength up to 550 deg. F., begins to lose its strength when this temperature is exceeded. At 1200 deg. F. it has only about one-third of its maximum strength.

It can thus be seen that if the tubes become overheated their strength will be much diminished and oxidation and burning of the metal will be likely. The internal surfaces of the tubes are scoured by steam, not by water; the temperature may be 350 deg. F. at the inlet rising to 500 or even 700 deg. at the outlet. In order that the tubes shall not overheat, the steam passing through them must conduct heat away from the metal as fast as heat is transmitted to it from the furnace gases. To secure this there must be a continuous flow of steam through the tubes under steam. If there is an additional saturated steam connection to the boiler, care must be taken to avoid withdrawal of saturated steam at such a rate that the tubes are starved of steam, as this would cause overheating.

Another cause of overheating is due to scale on the inside surface of the tubes. This coating, being a non-

conductor, hinders the heat transmission from the metal to the steam. A further cause is due to heavy firing of the boilers. Passing the furnace gases through the superheater when starting up, before the steam flow has commenced, also damages the tubes. This is sometimes overcome by filling the superheater with water before lighting the fire in the boiler. Objection to this is that if the water contains impurities they will be deposited in the tubes as scale. Water hammer set up when steam flow commences may also cause trouble if the water is not removed completely.

Scaling of the tubes is objectionable, for besides acting as a non-conductor, the scale will chip off in time and be carried by the steam into the engine or turbine. This scale also interferes with the superheat temperature. Impurities carried over with the steam when, if ever, the boiler primes, may also form scale.

Overheating is harmful since it causes weakening of the metal, oxidation, waste, bulging of the tubes and, in the case of welded tubes, possible failure at the joints. Localized overheating may occur through the accumulation of soot on the tubes. This usually takes place at the ends of the tubes where they are expanded into the boxes. Tubes should always be kept clear of soot as it not only causes the tubes to overheat and interferes with the superheat but is also liable to lead to corrosion of the metal. External corrosion will occur if soot collects on the tubes, if they are permitted to become damp as when the boiler may be taken out of service. Any tube leakages which occur should be stopped as soon as they are discovered expanding the tube ends.

London, England. W. E. WARNER.

Locating Furnace Air Leaks

AS THE DRAFT for a given stack height depends upon the temperature difference between the stack gas and the outside air, it follows that a given stack will have a greater draft during cold than hot weather and that for a given furnace temperature, the colder the weather the greater the draft. This means, in turn, that the colder the weather the more important it is to close up cracks and other sources of air infiltration, since the flow of cold air into the furnace will increase, due to the greater draft, while causing still further injurious effect upon combustion efficiency due to the lower temperature of the incoming air.

Air infiltration is so often discussed in connection with CO_2 that there is sometimes a tendency to feel that, because the engineer has no CO_2 instrument, he cannot detect air infiltration or dilution of furnace gases and so cannot effectively combat this major loss. This is not true, for while the CO_2 instrument or the portable orsat is a useful piece of equipment for every plant, it is much more important to know where the leaks occur than to know accurately how big they are. Chief leaks through which cold air is drawn into the furnace, may be located without any other equipment than a pair of eyes and a piece of chalk; or as alternatives, a newspaper or a candle. Not very expensive equipment to cut the fuel bill anywhere from 3 to perhaps 10 per cent, is it? Practically no effort is required, moreover, to make the tests described below; they may be performed at any odd time, without any preparation.

Air leaks into the furnace through cracks, crevices and interstices in the boiler setting and firebrick is pervious to some extent. While the voids, cracks and holes in the brickwork may be individually very small, the total area involved may be quite large, representing in the aggregate a large-sized channel through which air may seep.

Over-fire air, in some cases as high as 60 per cent is desirable, so that air leakage through the brickwork is not so injurious as air leaking in larger quantities through other places, because air seeping through the brickwork is warmed up while air leaking through big cracks is not heated, hence it not only dilutes the gases of combustion but cools them. The best way to reduce the air infiltration through the brickwork is to paint the brickwork with some product, developed especially for this purpose. When it is pointed out that an appreciable percentage of the ordinary brickwork consists of voids and air spaces through which air can flow, it is apparent how worth while it is to cover the outside surface of the entire brickwork with an impervious boiler setting compound of some sort. Suitable material for this purpose usually can be bought from the local gas works or coke producer at low cost.

To locate other cracks, which are the sources of the major individual leaks, any one of the following three tests may be carried out. Candle Test: Develop maximum suction in the stack by having damper wide open and a good hot clean fire on the grate. This develops a high temperature, hence intense draft. Pass a lighted candle close to and along the setting, moving the candle slowly over every part of the setting, especially alongside the metal work where metal and brickwork join. Where air is drawn into the furnace, the flame from the candle will also be drawn inward and in severe cases, will be blown out altogether. Where this test is performed periodically, it is a good thing to cut a piece of galvanized sheet iron about 1 ft. square, cutting out a hole in the center about 5 in. dia. By moving this plate over the brickwork, with the flame held in the center of the hole, it is possible to localize the leaks. When located, they should be marked with a piece of chalk so that they may be plugged up later.

Smoke Test: This test is even more simple than the one described. It locates smaller leaks than is possible with the candle test and does away with exploring. After intense draft is developed as before, throw several shovelfuls of green coal on the incandescent bed to make as much smoke as possible and immediately close the damper as tight as it will go. You will be astonished at the amount of heavy smoke that will be forced through many unexpected places. Wherever smoke is emitted, indicating a leak, the place should be marked. For this test, it is best to have several men on the job with chalk so that none of the leaks will be overlooked and that the boiler room is not smoked out.

Newspaper Test: This is practically identical with the candle test. Draft is made as intense as possible and a piece of newspaper measuring 6 in. or even a foot square is passed over the entire setting. Where the worst leaks occur and the suction into the furnace is most powerful, the paper may be held right against the brickwork due to the suction. This test is not as sensitive as the candle test, since the smaller leaks will not be discovered.

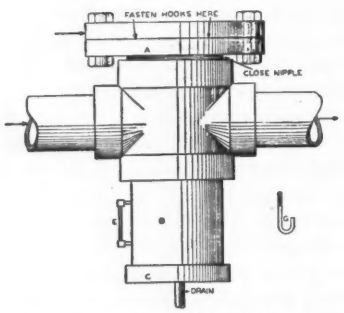
The smoke test is probably the best one to use and is the most impressive and so stresses the importance of stopping leaks. There are certain places where leaks occur most frequently. The entire setting should be explored but the following places give the most trouble: Wherever brickwork and metal join together; on top of boiler; around blowoff pipes, headers and header nipples of water-tube boilers; around the metal frames of observation and clean-out doors; between brickwork and boiler drums of water-tube boilers and between rear arch and boiler and for boilers in batteries, the division walls between boilers.

Try the smoke test and then if you want, buy an orsat or CO_2 instrument; meanwhile remember that the colder the weather the more costly is excess air and that the time to make the smoke test and close out the cold inrushing air is right now.

Chicago, Ill. C. G. Crowley.

Cross Fitting Makes Unique Steam Separator

Removal of water and oil from exhaust steam was satisfactorily accomplished in one instance by means of the simple device illustrated, which was made of parts usually found around any power plant.



PIPE FITTINGS AND CHAIN MAKE UP A GOOD STEAM SEPARATOR WHICH IS SATISFACTORY FOR MANY USES

Using a 4 or 5-in. by 2½-in. reducing cross fitting, a nipple, B, is screwed in the lower end and capped at the end C. A short nipple to fit the cross connects it with the lower of the companion flanges, A, the upper of which, F, is a blank flange. A number of hooks, G, made of ⅜-in. iron rod, are screwed into the lower part of flange, F, in a circular form having a diameter nearly that of the inside of nipple, B. Pieces of chain extending to within an inch or two of the cap, C, are hung from these hooks and the hooks closed to prevent the chains from being released.

Thus we have a column of chains hanging down in the center of the cross which entraps the water and oil in the steam passing in at one side and out of the other. A small pipe, which may be supplied with a valve, is screwed in the cap so that the water and oil may be drained off. The device may be supplied with a gage glass as shown at E.

Toronto, Canada. John Thorn.

Diesel Engine Cooling Water

Although ordinarily a minor item of expense, cooling water for Diesel engines is a matter of importance. Any water suitable for boiler feed will be suitable for water jacket cooling but the reverse is not always true. In the latter case, difficulty with hard water may be avoided by keeping the final temperature below the point at which the impurities precipitate. The water may be cooled for reuse by any of the usual methods. Preferably, the initial temperature should not be over 50 deg. F. and the discharge temperature may range from 75 to 110 deg. F. for hard water or up to 150 deg. for soft water.

Hobart, Ind. Harry J. Achee.

Keyways Repaired by Welding

Repair to a keyed connection was required because of heavy turning moment and impulsive action which wore down the keyways in both shaft and flywheel.

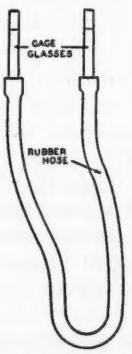
After the four keys used were withdrawn, the keyways, which were 90 deg. apart, were filled up by electric welding. New keyways were then cut in the old locations by means of a portable milling machine, after which fresh keys were fitted tightly at the sides but easy at the top and bottom.

London, England. W. E. Warner.

Simple Leveling Device

Leveling can be accomplished by means of a piece of hose and two pieces of gage glass, as illustrated, that cannot be done by an ordinary level.

In using this device, a mark is made in about the middle of each glass length at exactly the same distance from the outer ends. The tubing is then filled with water to these two marks. If on touching the under side of two ends of a shaft, or other object, with the ends of the gage glasses, the level of the water in each glass is the same distance from the shaft, the shaft will be level.



RUBBER HOSE AND TWO TUBES OF GLASS MAKE SIMPLE BUT ACCURATE LEVELING DEVICE

With graduated glass tubes it is easy to determine the pitch of pipe lines running through partitions or to detect sagging pipe lines that form pockets.

This device is simple and unfailing in accuracy.

Wichita, Kans. John Gaddis.

New orders booked during the first quarter of 1930, as reported to the Department of Commerce by 81 manufacturers of electrical goods, were $298,733,208, as compared with $288,696,415, for the last quarter of 1929 and $322,424,619 for the first quarter of 1929. These totals include motors, storage batteries, domestic appliances and industrial equipment, and probably sufficiently indicate the trend.

Questions and Answers

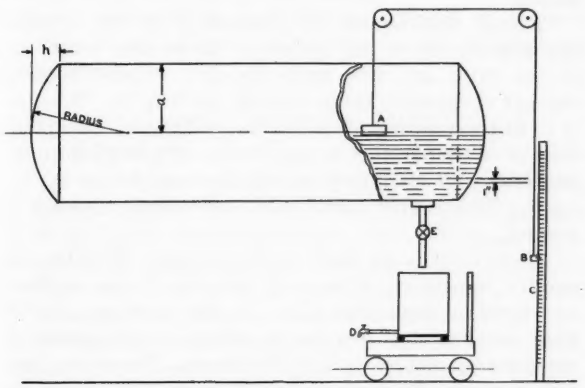
Tank Capacity Determination

How can the capacity of a horizontal tank with radial convex heads be determined mathematically and what is the formula for determining the volume in gallons for each inch of height of water in the tank?

J. T. S.

A. The formula for the volume of a tank such as you describe is 0.5236 h $(3a^2 \times h^2)$ in which the factors are those indicated in the illustration.

Exact mathematical determination of the volumes for various heights is a complicated process involving



DETERMINING THE VOLUME OF LIQUID FOR EACH INCH IN HEIGHT IN A COMPLEX SHAPED TANK

the use of calculus. There is, however, a simple way of making these determinations physically. If a pipe with controlling valve is attached to the lower side of the tank and is extended downward to a weighing tank on a platform scale, as shown in the sketch, you could fill the storage tank with water and empty it, step by step, an inch at a time, weighing the water each time.

To do this, it would be necessary either to attach a water glass which would be plainly marked for each inch or use a float indicator by which a float A on the surface of the water is connected by a rope running over pulleys to an indicator, B, which moves vertically on a gage board, C, which is marked with lines an inch apart. This gage board may be placed on the floor level, in which case the corresponding water level in the tank may be easily seen by the attendant.

To determine the volume in gallons at each inch mark, the following procedure may be followed: First, arrange the scale counter-balance weights so that when the weigh tank is empty the beam registers zero weight; then, having filled the storage tank with water to a point at which the float is still free to move, make a mark on the lower part of the gage board corresponding to a line on the indicator. With this mark as a base, make corresponding marks one inch apart above it on the gage board.

Having closed the valve, D, on the weigh tank, open valve E slightly and close it again promptly when the indicator mark corresponds to the inch mark just above the base line, then weigh the water in the weigh tank. Since 1 gal. of water at 62 deg. F. weighs 8.3356 lb. we determine the number of gallons of water for each inch of depth of water by dividing the weight of water, corresponding to that inch of distance moved by the indicator block, by 8.3356. By adding the volumes from zero height, we obtain the volume at each mark. These various volumes in gallons, thus determined, may then be marked directly on the gage board at their corresponding marks and since gallons are the same in volume for all liquids, these values apply also to fuel oil.

If closer determination is desired, the various values may be plotted on squared paper with inches in height on the horizontal scale and gallons on the vertical scale. In this way, if the height of water happened to be indicated on the gage board between any two marks, the number of gallons could be read off from the curve.

Steam Injection Nozzle Proportions

Why do the combining nozzle and steam nozzle in an injector have different areas? How do these ratios of areas vary with different types? V. J. M.

A. The relative areas of the nozzles are due to the different pressures under which they operate and to the quantities of fluid passing through them. The area of steam used per hour, can best be defined in terms of the area of the delivery tube. This varies with the pattern of the injector, and the purpose for which the instrument is designed. From superficial considerations, it would appear that, if this ratio were made unity, i.e., the steam nozzle area equal the delivery tube area, the jet would just have sufficient power to sustain the initial pressure. The nearest approach to this in experimental work is with the ratio 1.007 to 1.000 but in actual practice, on account of the necessity of a margin of counter pressure, the ratio varies from 2 to 1, 3 to 1; in the exhaust injector this is increased to 16 to 1, as the ratio of the initial to the terminal pressure is 1 to 6 or 16 to 96 lb. absolute.

Production of electric power by public utility power plants in the United States for March, 1930, reached a total of 8,164,080,000 kw-hr., an increase of 2 per cent over the output of March, 1929. Of the total amount, 4,904,227,000 kw-hr. were produced by fuels and the remainder, 3,259,853,000 kw-hr., by water power.

Editorial Comment

Private and Public Utility Power

Coöperation of industrial plants and central stations is not progressing as rapidly in this country as one might wish although engineers of both sides fully appreciate the advantages to be gained.

Judging from contemporary literature and opinions expressed by American engineers after foreign trips, Europe is considerably ahead of this country as far as the interchange of power between industrial plants and utility systems is concerned.

True, some headway has been made in this country and many such hookups are in service. One item which has hindered progress in this direction is the hesitancy of the industrial engineers in charge of operation to admit that power delivered to the utility system is worth only the fuel differential of production costs of the utility plant.

Standby capacity must be provided and, as the utility companies have no control over the industrial plant operation, it is difficult to tie these miscellaneous units into their systems. This disadvantage has been overcome in several cases by building a large utility plant adjacent to large industrial developments, designing the plant to meet the individual needs of the particular customer but retaining the control and operation of the station in the hands of the utility company, selling the bulk of the utility station output, both steam and electric, to the industrial plant and absorbing the surplus power or supplying the deficiency of power from the utility transmission system.

From the utility standpoint, this is advantageous but from the standpoint of many industries it has disadvantages and is not entirely in agreement with the independent policy upon which American industry is built.

Furthermore its application is limited to relatively large industrial plants and to well developed industrial centers, so that it would seem that a satisfactory solution will be found only when both sides are willing to recognize the advantages and disadvantages of such connections, not from their standpoint but from the opposite side of the fence.

By working together, designing the industrial plant to work in parallel with the utility system in such a way that reliance can be placed on the output of the plant or plants, the utility system will undoubtedly be able to eliminate much standby capacity and duplicate transmission facilities.

In this connection, it is interesting to review a discussion which took place before the Institute of Electrical Engineers about the Synthetic Ammonia and Nitrates Ltd. Plant in England. "——— As it stands, its owners obtain a very high economy for part of their own electrical power and ordinary economy for the rest. The capital outlay is large and the plant complicated. By leaving out their condensing turbines, they would have produced over double the electricity under high economy.

"——— It is doubtful if another such plant will ever be built. The nation needs all the power that can be produced at low cost as a whole or partial byproduct. . . . Not so many years ago no one would have suggested interworking between a private power supply and a public utility system. Today we wonder why this last of the greater private power stations was permitted to be quite so independent."

Power Control Through Heavy Current Tubes

While observing the operation of a small automatic electric grill in a restaurant recently a friend of the writer ventured the remark "Electricity seems to be able to do everything better than is possible by other means."

Though this remark was prompted by the appetizing appearance of the strips of bacon that came out of the grill, and was made casually without a great amount of thought, there is much truth in it. Whether it is in the toasting of bread, the grilling of bacon, the control of temperature or the driving of a battleship, the application of electricity in each instance brings advantages. This is true particularly as regards methods of control.

Electricity is an ideal control agent. Flexible, instantly responsive, delicate or forceful, it can perform any function demanded of it. In this issue appears the final installment of a series of articles on the control of synchronous motors by C. P. Robinson. Those who have followed Mr. Robinson's articles must have been impressed by the almost endless variety of control methods available for all classes of synchronous motor operation. Any desired performance characteristic can be met and no matter how complicated the procedure, the starting and stopping of such motors can be effected automatically with less risk than by hand.

No consideration of electric control today would be complete without taking into account the use of vacuum tubes. Thus far, all control operations have been effected through the use of magnets, thermal devices and in certain instances by chemical action. Today, however, a new principle of control is available in the almost infinite delicacy and flexibility of a steam of electrons in a vacuum tube.

Although the vacuum tube already has had many applications in the field of communication, its use in the power industry and in heavy electrical engineering has been limited due to the comparatively low current carrying capacities of the tubes available. Recently, however, a new type of tube has been developed called the thyratron which minimizes this limitation to such an extent that their general use for power control purposes seems almost certain.

For the past two years, there have been available hot cathode mercury vapor rectifier tubes which differ from ordinary vacuum tubes in that the electron emis-

sion takes place in an atmosphere of mercury vapor rather than in high vacuum. The thyratron is a development of this form of rectifying tube and incorporates in addition a control electrode.

Among the first extensive applications of the thyratron was the lighting control circuits of the new Chicago Civic Opera House. Used in conjunction with saturated iron core reactors and phase modulators, these tubes in this installation provide infinite variation in the dimming circuits.

Another possible application of the thyratron is its use as a controlled rectifier. In this use, it is the means of changing constant potential alternating current to variable potential direct current. As an inverter, that is as a device for changing direct current into alternating current, it should be useful where a number of different alternating-current frequencies are necessary.

A number of types of thyratrons have been developed, ranging in peak capacity from 1 to 75 amp. and from 1000 to 20,000 volts. Tubes of various power ratings are being manufactured and thyratrons capable of handling considerable power are under development.

Engineers concerned with control applications of any kind will do well to familiarize themselves with the characteristics of this new device, since it is destined to play an important part in this branch of electrical engineering.

Electric Clocks Indicate Quality of Service

No one factor in our daily lives is so universally depended upon as the element time. We sleep, eat and work by it. It enters into our business contracts, legislative enactments, legal procedure, election regulations. We travel on a time schedule, regulate speed of traffic in miles per hour, time our leisure moments and periods of amusements, make appointments according to clock indications. Doctors even judge our health by the heart beats and respiratory frequency per minute. An accurate time piece is essential to modern life.

In the face of this, the electric utilities of the country are advocating the use of electric clocks operated by electricity from their service lines. To give proper service these clocks must indicate time that is accurate to the second. Current interruptions of even infrequent occurrence are intolerable to the man who depends upon his electric clock. The utility company managers realize the requirements are extremely severe and yet they are confident that no other type of time piece will, for the money expended, give so complete satisfaction as the electric clock run on their service lines.

This service to customers is virtually a promise that the current will not only be continuous but that the frequency of alternation will be maintained constant within extremely narrow limits. Probably every owner of an electric clock checks up the accuracy of his instrument several times a month and draws a mental conclusion that the electric service is either good or poor. And still these clocks are growing more popular with the utility companies and the public.

What other utility, business concern, manufacturing plant or merchandising company undertakes such an exacting service as this? Back of the electric clock is the transmission and distribution system with transforming and switching gear whose reliability is contingent upon weather conditions, fires and floods.

The individuals of any utility company that maintains successfully such a service as electric clocks are to be complimented for their vigilence and constancy in their work, for the whole success of the service is a chain of individual efforts from the firemen to the line service men.

Byproduct or Waste Fuel

By making use of byproduct or waste fuel, modern power plants have contributed greatly to the economic development of certain industries, turning what was formerly a nuisance into a source of revenue.

Lumber and wood working plants with wood waste and steel mills with blast furnace gas are excellent examples of efficient utilization of byproducts or wastes that used to be difficult to dispose of. Savings result from two sources, the cost of disposing of the product as a waste and the cost of fuel formerly burned to supply the steam or power need of the industry.

Since the widespread introduction of cracking processes in oil refineries, petroleum coke is becoming of increased importance increasing from about 750,000 t. in 1924 to over 1,425,000 t. in 1928, the increase in 1928 alone amounting to over 425,000 t.

Petroleum coke ranges from dark gray to black and in appearance is somewhat similar to the coke made from coal. In the coking still the crudes are heated usually at atmospheric pressure until all but about approximately 8 per cent of the volatile has been reduced and the coke is left on the bottom of the still as a residue.

Modern cracking stills are operated above atmospheric pressures and the major portion of the coke produced is deposited in the reaction chamber. Differences in the chemical analyses and physical properties of cokes produced by the two methods differ sufficiently, as indicated above, to make it advisable to group them into two general classes, that is, coking-still and cracking-still coke although they may be and some times are further designated as "tower-still coke," "pressure-still coke," or "petroleum carbon" according to the particular cracking process by which they are produced.

Cracking-still coke, which is showing the big increase in production, can be further treated so as to become of increased importance as a source of industrial carbon. With the present unsettled condition of the oil industry, present fuel prices and the undeveloped market for this carbon product, further process treatments have not been considered advisable on a large scale and the power plant has stepped into the break giving an outlet for the coke which would otherwise prove embarrassing to the oil refinery.

This coke makes a good power plant fuel. It is being burned with success in a number of plants and is rapidly winning in popularity. It is cheap enough so that it offers a considerable advantage in certain localities at present and is sufficiently like coal that when industrial applications raise the price, it can be replaced with coal without pulverizer or furnace changes.

This is but another example of the part power plants play in the industrial development of our country. They not only supply heat and power on which industry operates but step in and relieve an embarrassing situation in this case forming a possible outlet for a byproduct valued at over $7,000,000 a year.

Power Plant Engineering Developments and News

Crawler-Mounted Flight Conveyor

ANOTHER new drag-type machine, the Model 57 crawler-mounted flight conveyor, has just been announced by Barber-Greene Co., Aurora, Ill. It is built to provide men who handle coal with a piece of

CRAWLER-MOUNTED FLIGHT CONVEYOR IN USE

light, inexpensive equipment with a rated capacity of a ton of coal or coke a minute, to unload, store, reclaim and screen.

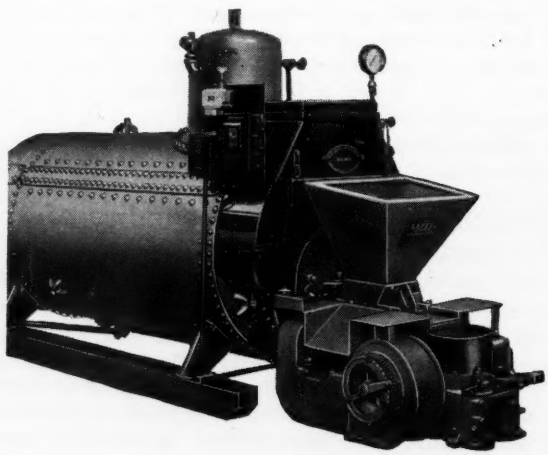
The unit is built in three boom lengths, 24, 30 and 39 ft. The conveyor boom is built in sections so that it may be lengthened or shortened if desired and is of structural steel hot riveted. The flights are of ¼-in. steel, cupped to exert a digging action. The whole boom is raised or lowered by power while the machine is running.

The new machine has a three-unit chain drive, each chain unit being of a fixed length, designed so that the tension on the chains does not vary. It is guarded against overload strains by the overload release sprocket, mounted on the head shaft, and held firmly to the outer part by two springs. It is designed to be a one-man machine, has a speed of from 26.28 ft. to 81.85 ft. per min. forward into the pile and will reverse at the rate of 21.65 ft. per min.

Stoker for Scotch Marine Boilers

FOR FIRING Scotch marine type boilers of the portable type, The James Leffel & Co., Springfield, Ohio, which makes this type of boiler, has developed a small automatic underfeed stoker. This unit, shown in the accompanying illustration, is made in sizes from 15 hp. to 200 b-hp.

It is designed to be quickly fitted to Scotch boilers now in use. It may be motor driven or steam turbine driven and is designed so that rate of firing and amount of combustion air are automatically regulated from the



LEFFEL UNDERFEED STOKER ON 20-HP. SCOTCH BOILER

steam pressure. Combustion air is supplied by a fan built integral with the unit. Gearing is totally enclosed, operating in an oil bath and the stoker is designed to require a minimum of attention. The illustration shows a complete steam generating unit consisting of boiler, stoker and automatic control equipment, assembled at the factory and mounted on skids.

Flow Proportioner for Corrosive Solutions

ACCURATE PROPORTIONING of one fluid to another is required in various processes, as, for example, in the softening of water. In some instances, however, the fluid to be controlled may be corrosive, as, for example, sulphuric acid solution, or otherwise of such a nature that it is not desirable to have it come into direct contact with the diaphragms or pistons of the balancing mechanism.

The air-balanced proportioner, Fig. 1, has been developed to overcome this difficulty. Referring to the sectional view, it will be seen that the corrosive solution is held at a constant level in a feed tank by a float-regu-

lated valve which controls inflow from a source of higher pressure, while the outflow of the corrosive solution is through an orifice. The pressure acting upon the outflow orifice is determined by the air pressure above the liquid level in the solution tank, this pressure being regulated automatically as follows:

Mounted upon the solution tank is a balancing device consisting of three corrugated bellows, all attached to a single movable diaphragm which carries on an axially placed tube a valve member co-acting with a stationary valve member at the top.

The surface of the diaphragm contained within the inner pair of bellows is acted upon beneath by the air pressure within the feed tank, while the upper surface

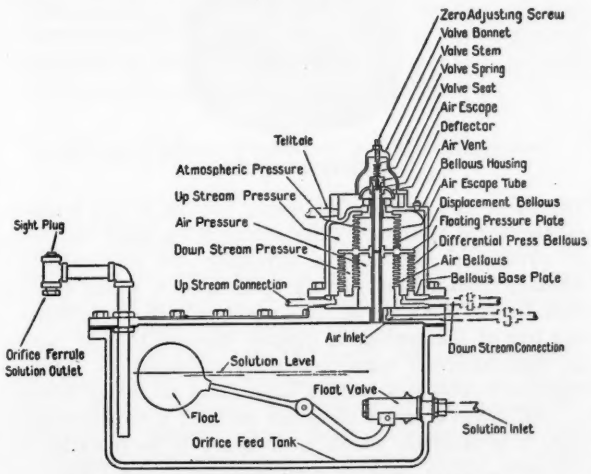


FIG. 1. AIR-BALANCED PROPORTIONER

is open to the atmosphere. The annular portion of the diaphragm outside of the inner bellows and within the outer bellows is acted upon, on its upper surface, by the pressure from the upstream side of an orifice in the primary flow pipe and upon its underside by the pressure from the downstream side of the same orifice.

The differential due to the flow of the primary liquid is thus balanced against the pressure within the orifice feed tank. Should the latter be greater in proportion than the differential due to the primary flow the valve member will rise and allow some of the air in the orifice solution tank to escape. On the other hand, should the differential pressure be the greater, the orifice member will fall so that no air can escape, but inasmuch as air is constantly flowing into the solution chamber from a supply source, the air pressure will build up until the valve will again be lifted. In other words, in operation the valve is always leaking more or less and the pressure within the orifice feed tank is always proportional to the differential due to flow of the primary liquid. The rate of inflow of air into the orifice feed tank is through a small orifice in the supply pipe. If the pressure of the source from which this air is taken in roughly more than twice the highest pressure carried in the orifice feed tank, the rate of inflow will be constant.

The tank from which the acid solution is received may be located below the air-balanced proportioner and the acid lifted up to the latter by admitting pressure from the primary air supply to the solution tank, Fig. 2. Similarly, the latter may be fitted with a calibrated measuring tank and with air-pressure connections so that acids can be charged into the solution tank without releasing the pressure on the latter. The supply for the proportioner may be also obtained from an elevated tank or by means of a constantly running centrifugal pump if desired.

To secure good mixing in the solution tank, various agitating means may be used, the one shown in the assembly drawing consisting of a perforated air pipe. In other cases, mechanical agitators may be employed.

The apparatus described has been developed by the Cochrane Corp., Philadelphia, Pa., for feeding sulphuric acid solution into boiler feedwater in order to correct abnormally high causticity and to aid in preventing caustic embrittlement in boilers.

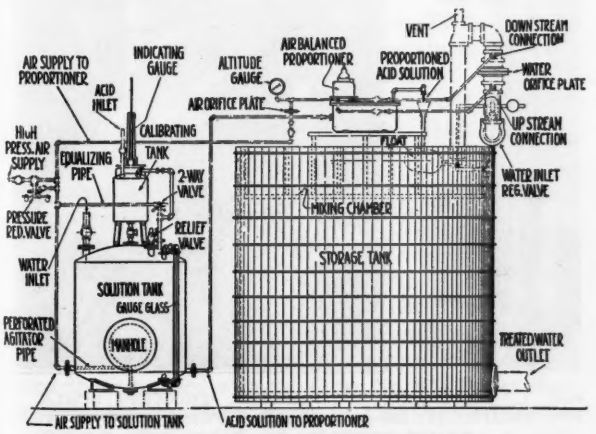
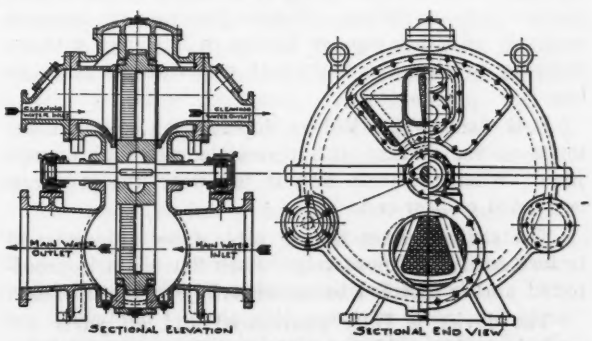


FIG. 2. ARRANGEMENT OF EQUIPMENT

Rotrex Strainer

ROTREX STRAINER designed to be automatically cleaned, as shown herewith, has recently been developed. No definite line, it is stated, separates applications of the basket type strainer from this automatic strainer. Use of the latter, however, is recommended where the quantity of water to be handled is so great as to require a strainer with baskets so large that they would be unwieldy to handle, also where, regardless of water quantity, material would accumulate too fast in a basket and necessitate frequent cleaning and constant attention. The automatic strainer is especially applicable to removing from water leaves, grass sea weed and other such material that often appears at flood periods.

The unit consists primarily of a stationary casing and a rotating straining wheel.



ELEVATION AND END VIEW OF ROTREX STRAINER

The bottom half of the casing carries the main water connections and the bearings for the wheel shaft. The top half of the casing carries the back wash water connections.

The strainer wheel is rotated continuously, driven through gear teeth on its rim, usually by a motor and reduction gear.

Spokes in this wheel divide it into sections; as each section passes the main water stream, refuse is deposited in the section. Rotation of the wheel carries this refuse up to the top of the casing where it is washed out under pressure through the refuse pipe.

This strainer is made in capacities from 4000 g.p.m. requiring a maximum 14-in. connection to 70,000 g.p.m. requiring a 60-in. connection. It is made by Andale Co., 1600 Arch St., Philadelphia, Pa.

Pipe and Fittings Tongs

VULCAN SUPERIOR Chain Tongs, shown here, designed for universal service on both pipe and fittings have recently been introduced by J. H. Williams & Co., Buffalo, N. Y.

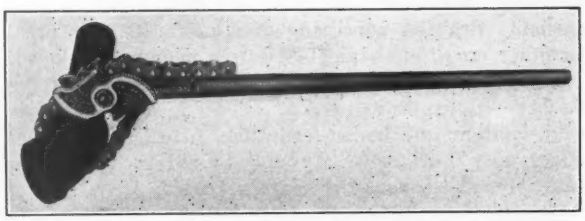


FIG. 1. VULCAN SUPERIOR TONGS WITH FLAT TYPE CHAIN

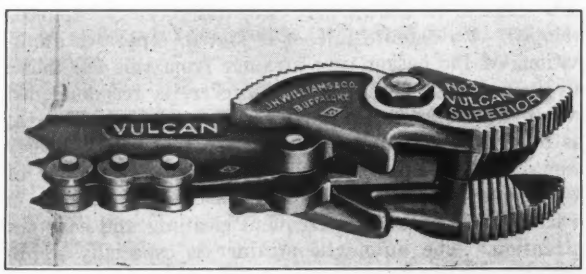


FIG. 2. DETAILS OF JAWS, SHOWING V NOTCH TO GIVE POSITIVE GRIP

The "V" recess in the jaws is to assure quick and positive grip on fittings. Vulcan Superior can be used instantly on either pipe or fittings, it is stated, without stopping to alter the tool itself and with no parts to lose.

It is claimed that Vulcan Superior is the only chain tongs on the market with reversible pipe and fittings jaws. When the teeth first in use wear, the jaws can be turned end-for-end.

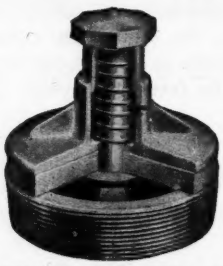
The chains, either flat or cable type, are designed to lock easily and positively. Each flat chain is proof-tested and is certified to assure safety to the operator.

The device is fully guaranteed and all parts are made interchangeable.

Combination Pump Valve

COMBINATION PUMP VALVE has recently been placed on the market in two types: Standard type B, for boiler feed, vacuum, condenser and general service pumps, shown in the illustration; standard type C, made of various metals to suit the conditions, as when handling high-temperature liquids or acids.

This valve is designed to lift straight and to reduce center wear on the stud, thus increasing the life of



COMBINATION PUMP VALVE CUT AWAY TO SHOW CONSTRUCTION

valve disc and putting the major portion of the friction on the valve assembly. The spring is enclosed not only to protect it but also to eliminate the possibility of damage from broken parts getting into the pump system and lines. Because of the uniform lift, it is stated, the life of the springs is greatly increased. The liquid in the telescope construction is intended to form a cushion to absorb a sudden blow from the valve lifting.

All types of valve discs can be used with this assembly, it is claimed, which is designed to be installed on any seat. It is made by Combination Pump Valve Co., 846 Wiota St., Philadelphia, Pa., in standard sizes from 3 to 7 in. varying by ¼ in.

Concentrometer, a Blowdown Meter

ELGIN CONCENTROMETER, shown here, is a concentration or blowdown meter recently placed upon the market by the Elgin Softener Corp., Elgin,

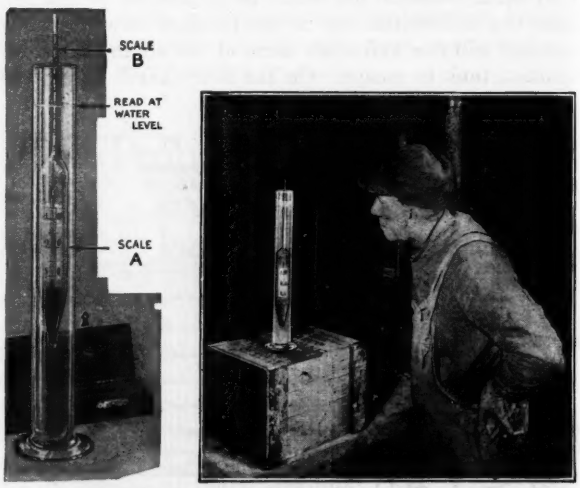


FIG. 1. LEFT—CONCENTROMETER, SHOWING SCALE A FOR TEMPERATURE AND SCALE B FOR CONCENTRATION
FIG. 2. RIGHT—METHOD OF USING THE CONCENTROMETER

Ill. This instrument is designed to show boiler concentration directly in grains per U. S. gallon. It consists of a combination thermometer and hydrometer, the thermometer having a graduated scale from 80 to 100 deg. F. The hydrometer scale, which reads directly in grains per U. S. gallon, is calibrated for every 10 grains and has a range from 0 to 500.

To use the device, a sample is obtained from the water column line after blowing out all stagnant water, about a quart being blown into a metal container where it is allowed to cool. This water is then poured into the sample jar and the concentrometer is lowered into it and allowed to find its own level. When the water sample has cooled to 90 deg. F., as shown by the thermometer scale A, scale B is read at the level of the water in the sample jar. Scale B is designed to show the concentration in grains per U. S. gallon. As the equivalent concentration varies with temperature, the reading should be taken at 90 deg. F.

The Philip Carey Co. to Make New Insulation

THE PHILIP CAREY CO., Lockland, Ohio, has recently become associated with the Aluminum Company of America in the production of a new high temperature heat insulating material to be manufactured under the trade name Carey Aluminite.

For the past two years the Carey research organization, the Mellon Institute of the University of Pittsburgh and the research department of the Aluminum Company of America have been coöperating in the development of a commercial high temperature heat insulating material derived from bauxite, the ore from which aluminum metal is produced.

These research efforts have proved so successful that The Philip Carey Co. is planning the erection of a $500,000 manufacturing plant at East St. Louis immediately adjacent to the Aluminum Company of America's ore plant, from which processed material will be delivered to the new Carey plant and there manufactured into insulating blocks, bricks and powder.

The new insulation is designed for use with electric furnaces, fire-brick boiler settings, heat treating furnaces, glass furnaces, regenerator chambers in iron, steel and other industries, and similar structures where internal temperatures range from 1800 deg. F. to 2600 deg. F.

The new insulation, it is stated, has ability to resist the disintegrating effect of high temperatures; in addition, it has excellent heat insulating value.

The Aluminum Co. of America is completely equipping its new electric furnaces at Alcoa, Tenn., with the new insulation.

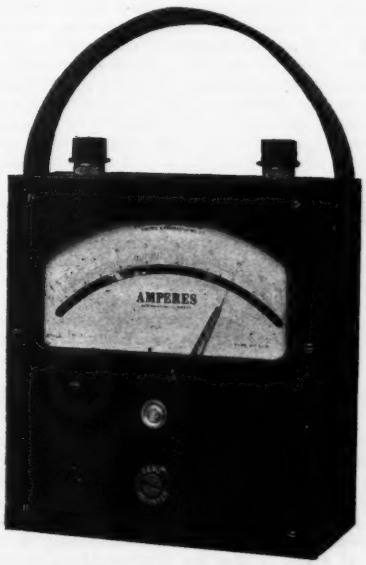
FEATURE of the new No. 414 Reamer, recently placed on the market by The Oster Manufacturing Co. of Cleveland, Ohio, is the screw feed, the pitch of which is so designed that tremendous pressure is exerted by the reaming blades. This is to eliminate the necessity for pushing against the tool to obtain sufficient pressure for a thorough reaming job. The reamer was designed primarily to be used with the Oster No. 414 Power Boy, but provision has been made so that two additional handles may be used for hand operation.

New Motor Starting Ammeter

WESTINGHOUSE TYPE PY-5 Motor Starting Ammeter is a new compact instrument which enables an accurate measurement of the instantaneous starting current of a.c. and d.c. motors, a measurement accomplished heretofore only with an oscillograph.

This instrument can be used also as an ordinary ammeter. Such measurements as starting current, locked-rotor current, and running current are made without disconnecting the instrument from the line. The instrument has a double range, and change over from one range to the other is accomplished simply by turning a switch on the side of the case.

This instrument, which is direct reading, is suitable for general testing and laboratory work, where especially high and positive accuracy is required and particularly on alternating current and, because of the permanence of calibration, for use as a transfer standard for calibrating and checking other instruments.



MOTOR STARTING AMMETER

To measure the motor starting current, the instrument is connected in the circuit like any other ammeter, but the reading is taken by the "set and try" method. The pointer is set to approximately the right position by means of the manually-operated stop and the power is turned on. If the setting proves high or low, the pointer is reset and a second trial made. A few trials may be necessary before final adjustment is reached, after which the needle will quiver just a little when the current is turned on, indicating that the maximum starting current is being measured. This indicator will be within 3 per cent of an oscillograph's exact record. After the reading is taken, the stop can be returned to zero.

The ammeter has a moving iron vane mechanism with an air chamber for damping the oscillations of the pointer. The moving element is quite light and very responsible to slight quick changes in current. The case is made of micarta with a walnut finish and nickel trimmings and is provided with a flexible leather handle.

News Notes

PUBLIC SERVICE Co. of Colorado is proceeding to install one 2500-hp. boiler at the Valmont Plant, near Boulder, equipped with air preheaters, induced draft and water cooled walls for the burning of pulverized coal. Work is in the hands of The Republic Construction Co., subsidiary of Henry L. Dougherty Co., and will be rushed to early completion.

CLEMENS HERSCHEL, hydraulic engineer and inventor of the venturi water meter, died on March 1 at the age of 87 yr. at his home in Glen Ridge, N. J. Mr. Herschel was born in Boston on March 23, 1842, and graduated at the Lawrence Scientific School, Harvard University, in 1860. He studied in France and Germany and graduated at the Carlsruhe Technical School in 1863. His career in hydraulic engineering began in 1879 when he become associated with James B. Francis in the work of the Holyoke Water Power Co. Under his direction, the famous Holyoke testing flume was built and conducted for about 20 yr. For a paper presented before the A. S. C. E., describing the invention of the venturi meter, Mr. Herschel was awarded the Rowland prize in 1888 and the Franklin Institute of Philadelphia awarded him the Elliott Cresson Medal for the invention. In 1889 Mr. Herschel became hydraulic engineer of the East Jersey Water Co. and continued with it until 1900. His consulting practice included such projects as those at Niagara Falls and the deep pressure aqueduct beneath New York City. He was the author of several textbooks and of many contributions to the engineering magazines and to the American Society of Civil Engineers. He was a member of the Boston Society of Civil Engineers, American Society of Civil Engineers, of which he was vice president and president, the American Water Works Ass'n and the Institution of Civil Engineers.

MATTHEW S. SLOAN, president of The New York Edison Company and associated companies, has announced that the General Electric Co. had been given a contract to build for the Hudson Avenue Station of The Brooklyn Edison Co. two turbine-generators of 160,000 kw. (215,000 hp.) capacity each, to meet the general growth of load on the system of five companies.

Total cost of the generators, boilers and other necessary equipment will be $18,000,000. Both machines are expected to be in operation in 1931. They will be of the most powerful single-shaft, single-unit design developed to date. The only other 160,000 kw. single-shaft, single-unit turbine-generator in the world is located in the East River Station of The New York Edison Co.

PENNSYLVANIA PUMP & COMPRESSOR Co., Easton, Pa., announces the appointment of E. H. Bollenbacher, 725 Forsyth Bldg., Atlanta, Ga., as sales representative in the Atlanta district.

AMERICAN PUMP & SUPPLY Co., Detroit, Mich., headed by F. W. DuBois, has merged its business with the sales organization of Tomlinson-MacLachlan, Inc. Simultaneously with this consolidation, A. H. Chas. Dalley, for the past 13 yr. western manager of the Superheater Co., became an active associate in the new organization, which will be known as Dalley & DuBois, Inc., with offices and warehouse at 464 West Jefferson Ave., Detroit.

ELLIOTT Co.'s New York and Chicago district offices have recently moved into larger and more comfortable quarters. The new address of the New York office is 2905 Transportation Building, 225 Broadway. The new location for the Chicago office is 1534 Twenty North Wacker Drive.

M. S. MALESON & Co., 606 Rockefeller Bldg., Cleveland, Ohio, and George H. Fredricks & Co., 216 W. Water St., Milwaukee, Wis., have been given exclusive sales rights for a water vapor cleaning device made by Homestead Valve Mfg. Co., Coraopolis, Pa.

AT THE TELL CITY PLANT of Ohio River Power Co., a new 1250-kw. turbine generator is being installed to replace a former damaged unit. Standby plants at Cloverport, Kentucky, and Cannelton, Ind., are operating in connection with the Tell City plant to handle the load until the new installation is complete. Hubert Cherry is superintendent of the Tell City plant of the Ohio River Power Co., a subsidiary of the Associated Gas and Electric System.

DE WATERS Automatic Safety Latch Corp. has been incorporated under the laws of Maryland and has taken over the assets, patents and facilities of the De Waters Safety Latch Co., Inc., a New York corporation. L. A. De Waters continues as president. The newly incorporated company has taken offices at 122 East 42nd St., Chanin Building, New York.

PAGE GOLSAN, recently Vice-President of the Great Western Portland Cement Co. of Kansas City, has just been appointed manager of the New Business Department of the engineering organization of Ford, Bacon & Davis of 39 Broadway, New York. Mr. Golsan was associated with this firm for many years and now returns to take charge of new business activities, covering the field of natural gas pipe line construction, industrial appraisals and management and other work.

ANNOUNCEMENT is made by Edward N. Gosselin, president of the Phoenix Manufacturing Co. that it has purchased and taken over on May 1 from the Graver Corp. its steel tank, water treating and steel plate construction business, including the plant at East Chicago, Ind., and the Phoenix Manufacturing Co. will operate this plant and business under a wholly owned subsidiary company to be known as Graver Tank & Mfg. Corp. The new company will maintain branch sales offices in Chicago (28 East Jackson Blvd.), New York, Dallas, Texas, St. Louis, Mo., San Francisco, Calif., and several other large centers. The general offices will be at East Chicago, Ind. Officers of the Graver Tank & Mfg. Corp. will be as follows: president, Edward N. Gosselin; vice-president and general manager, F. C. Everitt; secretary and treasurer, R. E. Meyer; vice-president in charge of sales, P. S. Graver; vice-president, W. F. Graver; vice-president, H. S. Graver.

AMES IRON WORKS Division of Pierce, Butler & Pierce Mfg. Corp. announces that its sales and service in the Chicago territory are now in charge of E. J. Friedrich of the Cochrane Engineering Co., 1223 Monadnock Block, 53 West Jackson Blvd., Chicago, Ill.

THE BROWN INSTRUMENT Co., Philadelphia, Pa., announces the consolidation of its Chicago Sales Office and Midwestern Factory Branch in new quarters located at 155 East Superior St., Chicago, Ill.

EDWARD VALVE & MANUFACTURING Co., East Chicago, Ind., has appointed the Taubman Supply Corp. its representative on the Oklahoma and northern Arkansas districts with headquarters at Tulsa, Okla.

SOUTHERN MANGANESE STEEL Co., until recently operated as a subsidiary of American Manganese Steel Co., Chicago Heights, Ill., has now become a part of the latter company, and will be operated as the Southern Manganese Steel Division of the American Manganese Steel Co. Effective May 1, 1930, it has opened an office in the Law & Finance Building, Pittsburgh, in charge of W. G. Hoffman. The company was formerly represented in this territory by Brooke L. Jarrett & Co. and C. E. Wallander.

KIELEY & MUELLER, INC., New York City, announces that it has appointed Walter H. Eagan & Co., 1612 Vine St., Philadelphia, Pa., as direct factory representative in the Philadelphia territory.

Catalog Notes

HEAT EXCHANGERS for Liquids are described in detail and their applications illustrated in Bulletin 12-H published by Schutte & Koerting Co., Philadelphia, Pa. These heat exchangers are used in oil refineries, chemical plants and other industrial processes.

SANDVIK STEEL BELT CONVEYORS and material handling machinery are described in Catalog No. 30 by Sandvik Conveyor Mfg. Co., 21 Amsterdam St., Newark, N. J. The catalog describes first the method of making the steel belt and then gives engineering data for selecting head and tail shafts and pulleys for steel belt conveyors. Various types of conveyors are described and illustrated by line drawings and the bulletin then gives details of pulleys, idlers, shafting, belting and other parts of the Sandvik conveyors.

TYPE 30 AIR COMPRESSORS, two-stage, air-cooled, ball-bearing units, made by Ingersoll-Rand Co., 11 Broadway, New York, as described in a recent issue of Power Plant Engineering, are discussed in detail with illustrations, tables of capacity and so on, in a new bulletin just issued by the company. It has also issued another well illustrated catalog on Class PRE Compressors giving complete details of the units and their applications. These are units with capacities up to about 8000 c.f.m. Another bulletin is entitled 100 and 1 Ways to Save Money with Portable Compressors, Seventh Edition, Revised. Still another describes Type 20 Portable Air Compressors, while Class ER and RF Straight-Line Compressors and Vacuum Pumps and Duplex Compressors, belt-driven and direct-connected for electric-motor drive are discussed in other bulletins.

METHODS OF STIMULATING employee interest in safety by developing the spirit of friendly competition or the desire to excel are presented in a report entitled "Safety Competition," published by the Policyholders Service Bureau of the Metropolitan Life Insurance Co., New York City. This publication is the seventh of a series of Industrial Safety leaflets, based on a study of the field of safety engineering and outlining effective methods of applying the principles governing successful accident prevention work. A copy of this study and the six previous leaflets in the series may be had upon application to the company.

SAFETY INSURANCE FOR THE BOILER ROOM is the title of a 12-page bulletin describing the De Waters Automatic Safety Latch, for holding boiler firing doors closed against any sudden release of pressure in the furnace. Its design, intended to meet the requirements of the A. S. M. E. Boiler Code and other require-

ments of inspection authorities, is discussed in detail, also its application to various types of doors. The bulletin is published by De Waters Automatic Safety Latch Corp., Chanin Bldg., New York City.

DESCRIPTION of Tanner-Tanks and Tanner gas, a system for prevention of freezing in compressed air lines and at the exhaust of compressed air tools, is given in a folder issued by Sullivan Machinery Co., 701 Wrigley Bldg., Chicago, Ill. Connected as a bypass near the point of use, the Tanner gas mixes with the air in the line, becoming an active agent which prevents freezing down to 40 deg. below zero.

WATER COOLING TOWERS is the title of a new 37-page booklet just issued by the C. H. Wheeler Mfg. Co., Philadelphia. Elements of water cooling practice, as applied to forced and natural draft and special type towers built by this company, are covered in detail.

BLACK SERVANT, The Automatic Coal Stoker, an automatic unit designed for heating system boilers and feeding coal by means of a worm screw conveyor, is described in a recent bulletin by Black Servant Manufacturing Co., No. Market at Garrison St., St. Louis, Mo.

DESIGNS AND APPLICATIONS of Rex-Stearns Timken Idlers for all types of belt conveyors, together with all allied and auxiliary equipment for complete belt conveyor installations are described in a recent 96-page well illustrated bulletin by The Stearns Conveyor Co., Cleveland, a division of Chain Belt Co., Milwaukee, Wis. The book contains many engineering data such as dimensions, detailed drawings and discussions of both principles and details of equipment. It also covers briefly Rex-Stearns Glass Plant Systems and Silo Storage Systems.

SYKES GEAR GENERATORS for the production of the Sykes continuous tooth herringbone gears are described in all types and sizes in a recent 24-page bulletin sent out by Farrel-Birmingham Co., Inc., 344 Vulcan St., Buffalo, N. Y.

THE YEARBOOK FOR 1930 of the Public Service Co. of Northern Illinois, 72 W. Adams St., Chicago, Ill., is an attractive 32-page bulletin describing the operations of the company, its various plants and showing by interesting charts and diagrams its general financial condition.

FACTS AND FIGURES About Steel Construction are given in a 126-page illustrated bulletin just issued by American Institute of Steel Construction, Inc., 200 Madison Ave., New York City. The book contains data on the history of the Institute and its organization with discussion of its various activities, followed by technical data on structural work, construction values, buildings, bridges and other steel construction, followed by a glossary of terms used by steel men.

CHEVENARD, INDUSTRIAL Thermal Analyzers and Differential Dailatometers, consisting of equipment for scientific study of steel, alloys and various products such as refractories, glass, silica bricks and so on, are described in a recent catalog issued by The R. Y. Ferner Co., Investment Bldg., Washington, D. C. This catalog, No. D-1, describes an Industrial Thermal Analyzer, a Differential Dilatometer registering photographically and mechanically, a galvanic pyrometer and other precision instruments. By the use of these, curves can be obtained which show variations in specimens under test.

VENTURAFIN METHOD of Heating for floor, wall or ceiling mounting and for high, medium or low pressure steam applications, is described and illustrated in detail in a 24-page attractively printed bulletin No. 9218 issued by American Blower Corp., Detroit, Mich. Details and assembly of the various Venturafin unit heaters are given with piping diagrams, dimension drawings and tables and tables of capacity,

SCOTCH MARINE BOILERS and steam engines are described in Bulletin No. 216 by The James Leffel & Co., Springfield, Ohio. These include Scotch Marine type portable boilers, ranging in size from 6 to 200 hp. and arranged for hand firing, stoker firing with the Leffel stoker or oil firing. Construction details of these are given, tests of a typical installation and the bulletin concludes with details of Leffel horizontal center crank steam engines, built in sizes up to 40 or 45 hp.

COPPUS STEAM turbines from 1 to 60 hp., also in fractional horsepowers, steam turbine generators from 1 to 18 kw. for direct current and Coppus heat killers, blowers, exhausters as well as the CM blower for industrial ventilation and undergrate forced draft, and the vertical hot gas propeller blower, are described in detail in a recent bulletin by Coppus Engineering Corp., Worcester, Mass. Most of the equipment designed is specially adapted for oil refineries.

M-K-O AUTOMATIC BOILER FEED for maintaining a constant water level in high or low pressure boilers is described in detail in catalog No. 4 by Mears-Kane-Ofeldt, Inc., 1903 E. Hagert St., Philadelphia, Pa.

NUVEYOR PNEUMATIC Ash Conveyor is described and illustrated in a bulletin just issued by the United Conveyor Corp., 37 W. Van Buren St., Chicago, Ill.

TONCAN IRON PIPE, its physical and chemical characteristics, applications, methods of manufacture and results of use, are fully discussed in a 32-page illustrated bulletin entitled Pipe for Permanence with Toncan Iron Pipe, issued by Republic Iron & Steel Co., Youngstown, Ohio.

STRUCTURAL STAIR TREADS and door saddles made of Feralun are described in a circular recently issued by American Abrasive Metals Co., 50 Church St., New York City.

AMERICAN-MARSH Type Q Centrifugal Pump, a single stage unit for handling comparatively small volumes of liquid for heads up to 300 ft. is described in detail in a catalog, bulletin No. 64, issued by American Steam Pump Co., Battle Creek, Mich. The pump is made in capacities from 5 to 35 gal. per minute.

TYPE AA RELIANCE Induction Motors with ball bearings for two and three-phase alternating-current circuits are described in Bulletin No. 106 by Reliance Electric & Engineering Co., Ivanhoe Road, Cleveland, Ohio.

THE JONES GAS DETECTOR, an instrument for practical field use intended to show the approximate explosive content or oxygen deficiency of atmospheres in confined spaces, is described in a circular by Mine Safety Appliances Co., Braddock, Thomas and Meade Sts., Pittsburgh, Pa.

BROWN REMOTE TYPE INSTRUMENTS are completely described and illustrated in a 32-page catalog No. 7501 just issued by The Brown Instrument Co., Philadelphia, Pa. Sectional views and wiring diagrams amplify the descriptive material. These remote type instruments, designed to furnish data from distances of a few hundred feet up to 30 mi., are furnished in models designed to control, record and indicate flow, pressure, liquid level and position.

TESTS OF LARGE timber columns and presentation of the Forest Products Laboratory Column Formula are contained in Technical Bulletin No. 167 of the United States Department of Agriculture, Washington, D. C. This is a paper by J. A. Newlin, principal engineer in charge, and J. M. Gahagan, assistant engineer, and is for sale by the Superintendent of Documents at Washington, D. C., price 15 cents.

TURBINES BY MURRAY for generator units are described in a new publication issued by Murray Iron Works Co., Burlington, Iowa. This bulletin shows complete unit, also describes and illustrates details of construction of rotors, bearings, governors and so on, and shows extraction mixed-pressure turbines and reduction gears. These turbine-generator units are built in capacities up to 2000 kw. Another bulletin recently issued by the company describes Murray turbo-gear units, both type X and Y, in sizes 2 to 100 hp. A third bulletin describes and illustrates in detail Murray turbines for pump drive. These are built to drive boiler feed pumps, fire pumps, water works pumps, also hotwell, circulating, oil and sewage disposal pumps.

PATTERSON HOT WATER Service Heaters, preheaters and converters are described in catalog No. 15 just issued by The Patterson-Kelley Co. Capacity, sizes and weights of the heaters are given in tables, their construction is described and illustrated in detail and their applications are discussed. The company is also issuing a folder describing the Kelley Reclaimer for reclaiming waste heat in laundries and industrial plants.

ELECTRICAL CO_2 METERS are discussed in Bulletin No. 781 by Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa. The bulletin discusses the need for CO_2 meters, relation of CO_2 to excess air, general combustion principles and then gives details of the thermal conductivity of CO_2 meters, comments on design, discussion of details, price list, typical installation, outline and drilling dimensions. In catalog No. 20 the company describes galvanometers, giving complete details of their construction and prices and ranges of the instruments.

NOTES ON USES of Nickel Cast Iron are given in a new bulletin by The International Nickel Co., Inc., 67 Wall St., New York City. Outstanding applications of this alloy are classified under five important industrial fields for reference by designing engineers or manufacturers of equipment employing cast iron. The booklet is in handbook size and discusses the use of nickel cast iron in the automotive, aeronautical, general machinery, machine tools and power field.

LONGITUDINAL DRUM Water-Tube Boilers, made by Union Iron Works, Erie, Pa., are described in a 52-page illustrated bulletin published by that company and distributed by James T. Castle, 424 First Ave., Pittsburgh, Pa. The catalog discusses fundamental principles of design, features of the longitudinal drum boiler, details of parts, instruction and cleaning facilities and similar details, illustrations of manufacturing processes are given, together with cross section drawings of typical installations of these boilers.

Power Plant Construction News

Calif., Berkeley—The B. F. Sturtevant Co., Hyde Park, Boston, Mass., plans installation of electric power equipment in proposed plant at Berkeley, for the manufacture of mechanical draft apparatus, entire project to cost more than $500,000.

Calif., Los Angeles—The Pacific Clay Products Co., Chamber of Commerce Building, plans installation of electric power equipment in proposed new addition to sewer pipe manufacturing plant, entire project to cost about $150,000.

Conn., Waterbury—The American Brass Co., Waterbury, plans installation of electric power equipment in proposed new one-story plant unit, 160 x 200 ft., entire project to cost over $200,000.

Ga., Douglasville—The Douglasville Hosiery Mills, Inc., plans installation of electric power equipment in proposed addition to plant, entire project reported to cost more than $75,000.

Ill., Chicago—The Commonwealth Edison Co., 72 West Adams Street, has plans under way for a one-story power substation, to be known as the Calumet substation, reported to cost over $75,000, with equipment.

Ill., Winnetka—The Village Council has plans maturing for a proposed addition to steam-operated municipal electric power plant for increase in generating capacity, reported to cost close to $350,000, including waterworks expansion. Bids will soon be asked on general contracts. The Byllesby Engineering & Management Corporation, 231 South La Salle Street, Chicago, is engineer.

Ind., Marion—The Indiana General Service Co., Marion, has plans under way for a new power substation, as well as new equipment storage and distributing plant, entire project to cost over $250,000.

Ky., Vanceburg—The Common Council is said to be planning the installation of pumping machinery and auxiliary equipment in connection with extensions and improvements in municipal waterworks. The H. S. Herr Engineering Co., Terre Haute Trust Building, Terre Haute, Ind., is engineer.

Md., Hagerstown—The Atlantic States Service Corporation, Hagerstown, plans rebuilding of portion of local ice-manufacturing plant, recently destroyed by fire with loss reported at more than $40,000, with equipment.

Mass., Chicopee—A. G. Spalding & Brothers, Inc., Chicopee, plan installation of electric power equipment in connection with proposed rebuilding of portion of solvent plant at sporting goods factory, recently destroyed by fire with loss reported in excess of $100,000.

Mich., Flint—Board of Trustees, New Borgess Hospital, Gull Road, Kalamazoo, Mich., is completing plans for a power house in connection with a new institutional building at Flint, entire project to cost about $1,000,000. Bids will soon be asked on general contract. D. A. Bohlen & Son, Majestic Building, Indianapolis, Ind., are architects.

Mich., Portland—The Village Council is said to be planning extensions and improvements in municipal power plant, including installation of additional equipment, estimated to cost about $50,000. F. L. Jenkins is general manager at plant.

Mo., Concordia—Board of Control, St. Paul's College, Concordia, has preliminary plans under way for a one-story power plant at institution, estimated to cost about $35,000, with equipment. Lewis B. Wilson, Walsix Building, Kansas City, Mo., is architect.

Neb., Grand Island—The Central Power Co., Grand Island, has plans under way for a new steam-operated electric power plant, reported to cost about $40,000. A. D. Baker, Clinic Building, is architect.

N. J., Elizabeth—The Allied Tar & Chemical Corporation, South Bayway, plans installation of electric power equipment in connection with proposed rebuilding of portion of plant, recently destroyed by fire with loss reported over $500,000.

N. Y., Syracuse—The Pierce, Butler & Pierce Mfg. Co., 282 James Street, plans installation of electric power equipment in connection with proposed rebuilding of portion of boiler and heater manufacturing plant, recently destroyed by fire with loss reported in excess of $500,000.

N. D., Minot—The Northern States Power Co., 15 South Fifth Street, Minneapolis, Minn., has approved plans for an addition to steam-operated electric power plant at Minot, to include installation of additional equipment.

Okla., Muskogee—The Construction Division, Veterans' Bureau, Washington, D. C., will receive bids until June 10, for a boiler plant, incinerator, steel water tank, radial brick stack and electrical work for the Veterans' Hospital at Muskogee, as per plans and specifications on file.

Okla., Oklahoma City—P. O. Denham, 701 North Western Avenue, and associates have plans for a one-story ice-manufacturing plant on local site, to be equipped for an initial output of about 30 tons per day.

Pa., Billmeyer—J. E. Baker Lime Co. plans installation of steam power equipment in connection with proposed rebuilding of plant recently destroyed by fire with loss of about $70,000, including kiln units, etc.

Pa., Philadelphia—Lit Brothers, Eighth and Market Streets, operating a department store, have filed plans for a one-story power plant, 20 x 127 ft., on Filbert Street, near Seventh Street, to cost $200,000, with equipment. Simon & Simon, Fidelity Building, Philadelphia, are architects.

Pa., Philadelphia—Gabriel B. Roth, 1629 Chestnut Street, architect, is preparing plans for a boiler plant and three-story factory on Hunting Park Avenue, to cost over $80,000, for a company whose name is temporarily withheld.

S. D., Elk Point—The Common Council, Elk Point, has approved plans for extensions and improvements in municipal electric power plant; additional equipment will be provided. Estimated cost not announced.

Tenn., Memphis—The Kaye Ice Co., 624 Union Avenue, is said to be planning a one-story addition to ice-manufacturing plant to cost close to $40,000, with machinery. Frank Kaye, Jr., heads the company.

Tenn., Memphis—The Memphis Power & Light Co., Memphis, is said to be planning extensions and improvements in steam-operated electric power plant at Fourth Street and Iowa Avenue, including installation of boiler units and auxiliary equipment to cost more than $250,000.

Texas, Dallas—The Texas Potash Corporation, Republic Bank Building, plans installation of electric power equipment in proposed new potash mining and refining plant in Midland County, entire project to cost over $500,000. A boiler plant is planned.

Texas, Denton—The City Commissioner is planning construction of a pumping plant for municipal water service at West Denton, where site has been acquired on West Prairie Street, estimated to cost over $40,000, with equipment.

Texas, Sherman—C. C. Mayhew, Sherman, and associates have approved plans for a one-story ice-manufacturing plant on West Houston Street, to cost about $50,000, with equipment.

Texas, Stratford—The West Texas Utilities Co., Abilene, is said to have approved a fund of about $100,000, for proposed extensions and improvements in electric light and power plant, and waterworks at Stratford, recently acquired. Work will include installation of additional equipment for increased capacity.

Wash., Seattle—The Puget Sound Power & Light Co., under the direction of Stone & Webster Engineering Co., Boston, Mass., has arranged for a bond issue of $9,000,000, a portion of proceeds to be used for expansion and betterments in power plants and system.

Wash., Tacoma—The Puget Sound Lumber Co. plans installation of electric power equipment in connection with proposed rebuilding of portion of saw mill and lumber plant, recently destroyed by fire with loss reported over $300,000.

Wis., Milwaukee—The Wrought Washer Mfg. Co., 46 South Bay Street, plans installation of electric power equipment in proposed new plant addition, including rolling mill, entire project to cost over $125,000. Fred Doepke is president.